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Reduce, Reuse & Regulate: An Assessment of Industrial Waste and Water Management Practices and Limitations to Compliance in Windhoek, Namibia

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AN ASSESSMENT OF INDUSTRIAL WASTE AND WATER MANAGEMENT PRACTICES AND LIMITATIONS TO COMPLIANCE IN WINDHOEK, NAMIBIA

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ABSTRACT

As Windhoek urbanizes and industrializes, increased pollution threatens the water supply. Our project assisted the city's Department of Infrastructure, Water & Technical Services by identifying limitations to compliance and determining strategies for improved enforcement of industrial effluent regulations. By gathering information via interviews with personnel from regulatory organizations and industrial operational managers, we found that effective industrial regulation is limited by inefficient communication between regulatory authorities and the inconsequential nature of regulatory enforcement. We developed recommendations for improved enforcement of regulations, improved industrial compliance, increased community involvement, and opportunities for future research.

EXECUTIVE SUMMARY

Africa hosts some of the most rapidly growing, underdeveloped nations in the world. Inadequate access to safe drinking water is a growing concern for these nations, as rapid urbanization outpaces water provision infrastructure.

As the most arid country in sub-Saharan Africa, no country faces this challenge more than Namibia. The capital city of Windhoek, located over 550km from the nearest river, experiences 200-300mm annual rainfall concentrated during the country's rainy season (Hyens, 2004). Windhoek's 380,000 residents rely on the city's innovative technologies for water. In 1933, the city installed a series of dams for emergency water supply during droughts. In 1969, the city pioneered a water reclamation system, recycling treated wastewater back into the city's water system.

Despite these innovations, Windhoek's rapid industrialization and urbanization since Namibia's independence in 1990 threaten the city's water supply. The water supply within Windhoek's dams has steadily decreased over the past four years. Increased water pollution threatens the quantity and degrades the quality of this vital resource. Pollution originates from untreated industrial effluents and is exacerbated by inefficient regulation of industrial discharge. City water experts predict that if conditions do not improve, Windhoek will run out of water by March of 2016 (Hambabi, M. and Ivondia Karumendu, personal communication, March 24, 2015).

The severity of Windhoek's water situation makes it a priority for the City of Windhoek's Department of Water, Infrastructure and Technical Services (DIWTS). The DIWTS is responsible for the regulation of industrial effluents and the management of the city's water. The DIWTS requested this project to gain insight on how increased industrial pollution contributes to the deteriorating water quality.

METHODOLOGY. The goal of this project was to assist the DIWTS reduce the pollution of water resources by identifying the limitations to compliance and determining strategies for improved enforcement of regulations. To accomplish this goal, our objectives were:

1. Review governmental regulations and industrial best practices concerning industrial waste and water management and identify inefficiencies within the regulatory system.
2. Investigate limitations to compliance with city regulations for industrial chemical effluents and water consumption practices.
3. Investigate industrial personnel's knowledge of Windhoek's water provision challenges.

To complete our goal, we used followed methods, adapted from best practices:

1. Interviewed representatives of governmental regulatory organizations to understand the industrial regulatory process.
2. Researched best practices for regulation of industries in developing countries to compare with Windhoek's regulation.
3. Toured Windhoek's water reclamation and treatment plants, speaking with operators about challenges with industrial effluent quality.
4. Interviewed industrial operational managers, investigating current practices, challenges for regulatory compliance, motives to comply, and additional support industries need.
5. Surveyed industrial production employees regarding Windhoek's water provision challenges.

FINDINGS. We identified inefficiencies within the regulation of industrial water use and effluent disposal as well as industries' limitations to regulatory compliance. The following sections outline our findings:

1. The complexity of regulatory agency responsibilities and the inconsequential nature of the legislation they enforce contribute to ineffective enforcement of industrial regulations. Interviews with regulatory organizations revealed two factors that prevent effective regulation: the enforcement process and the content of the regulatory policies. Regulator responsibilities are scattered amongst three national ministries and local government. Communication between these agencies is slow or nonexistent. Enforcement of regulations is based solely on dialogue and effluent charges as the content of the regulatory policies lacks specific consequences for regulatory infractions.

2. As major providers of services or products in the Namibian economy, Windhoek's critical industries create complexities in enforcement of regulations. Several companies in Windhoek are the sole supplier of their respective product or service. These critical industries drive Namibia's economic prosperity and are essential for the supply of goods to Namibian citizens. Although these industries serve a vital role, their presence complicates enforcement of industrial water and waste regulations. Legislation has a limited effect on these industries, as fines for water use and effluent concentration are insignificant relative to company revenue. While these industries attempt to manage their water and effluent to varying degrees, their ability to operate is rarely threatened regardless of their compliance status.

3. Unregulated industries within Windhoek's expanded boundaries, informal settlements, and growing industrial sector hinder consistent enforcement of regulations. Interviews with industrial managers and government representatives uncovered the lack of uniform of enforcement of effluent regulations. The expanded city boundaries cause formerly unregulated industries to fall within the regulatory jurisdiction of the DIWTS. The DIWTS does not have adequate resources to properly manage the newly encompassed industries' improper waste disposal, inadequate effluent treatment, and deficient knowledge of regulatory processes. Companies in the informal settlements lack proper facilities, knowledge of regulations, and finances to be properly regulated by the DIWTS. Lastly, industry growth adds another layer of regulatory difficulty: as small industries begin to expand their processes, they continue to go unregulated by the DIWTS.

4. Rather than regulatory penalties, three motives—corporate responsibility, company values, and international image—drive industrial managers to improve waste and water management processes. Company managers often do not understand their effluent charges, nor do they feel a strong obligation to lower effluent concentrations. These fines are viewed as an operational cost. Most companies are motivated by a sense of environmental responsibility due to the extreme drought conditions. Managers strive for their companies to operate in ways that cater to the environment as well as company success. Company values are also a large motivating factor for efficient water use and effective effluent treatment. As these values are instilled, employees become mindful of their practices when involved with water and in the effluent management process. Finally, international image motivates industrial managers of international companies. To appear attractive in the global market, managers feel a sense of responsibility for efficient and responsible operations.

5. Operational managers are aware of Windhoek's state of drought, but four factors hinder their efforts to adapt industrial practices and address the water crisis: monetary investment, time investment, company growth, and lack of knowledge of best practices. All industrial managers discussed the dire situation surrounding water in Windhoek. While concerned for the city's future, managers spoke of the following four challenges that inhibit their efforts to adapt practices to address their concerns.

- *Monetary investment*. Surcharges levied under current water consumption and effluent discharge billing system are cheaper than implementing up-to-date technology.
- *Time investment*. Managerial responsibilities and dedication to production time inhibit improvement of practices or infrastructure.
- *Company growth*. Growth impedes efforts to adapt as demand for a company's product results in increased water use and effluent quantities.
- *Lack of knowledge of best practices*. Managers are limited by their understanding of how to implement new technologies to treat effluent and save water.

6. While employees genuinely care about the city's water supply and economic success, their minimal knowledge levels and resistance to change workplace practices impede efforts for water conservation and effluent compliance. Industrial managers commented on the challenges in relation to employee skill level when new systems are implemented: minimal knowledge level of water processes and resistance to change practices. Survey results showed that while employees genuinely care about the city's water, environment, and economic success, these attitudes do not directly translate to practices in the workplace. As company management continues to make strides to implement technologies to conserve water and treat effluent, employees must learn to adapt. Without training, attitude shift, and behavioral modification, implementing technology is ineffective. While most interviewees are the ideal candidates for implementing effective training programs in their companies, they usually hold other responsibilities that monopolize their time.

RECOMMENDATIONS. Our findings show that a significant problem for industrial regulation is poor communication. Regulatory agencies must improve communication with industries, the public, and other regulatory bodies. We have developed seven recommendations classified into the following four categories:

- Recommendations for Improved Enforcement of Regulations
- Recommendations for Improved Compliance to Regulations
- Recommendations for Increased Community Involvement
- Recommendations for Future Research

Recommendations for Improved Enforcement of Regulations

1. Establish a new water forum involving representatives from regulatory agencies to address communication flaws and develop a consistent system of industrial regulation. Our interviews uncovered a lack of communication between all regulatory organizations. Poor communication inhibits the effectiveness of industrial water use and effluent regulation. We recommend the establishment of a new water forum to focus on managing industrial waste and water by appointing the most relevant individuals from each regulatory agency. This forum should serve as the primary source of approval for new industries, and establish a consistent method for enforcing regulations.

Recommendations for Improved Compliance to Regulations

2. Provide recognition and a monetary incentive for industries to comply with regulations by reducing water usage and improving effluent treatment. Our interactions with industrial managers revealed that managers view regulatory fines as a cost of conducting business, which is not an effective motive to improve water and waste management practices. We suggest that the City of Windhoek implement two industrial incentive programs:

- Award a yearly subsidy and environmental sustainability certificate to the company that shows the most improved results for water consumption and effluent quality.
- Provide a cost reduction from regulatory fines for industries that plan to implement new effluent treatment systems to help finance the construction of these technologies.

Both the regulatory authorities and industries must invest in these programs for optimal results.

3. Develop a program to meet regularly with industrial managers to improve transparency of regulations, build personal relationships, increase cooperation between the city and managers, and improve regulatory compliance. Industrial managers discussed the desire for increased interaction with city officials. We recommend that these meetings occur on a quarterly basis with the seventeen industries currently monitored by the DIWTS. These meetings will provide opportunities for city representatives to explain industrial water and waste charges and serve as a platform to suggest feasible techniques for treating effluent and saving water.

4. Require that industrial management develop a water-conservation training program for employees to address the effects of two factors—minimal knowledge of water processes and resistance to change practices—on regulatory compliance efforts. Our conversations with industrial managers revealed that employee practices and behaviors hinder the companies' efforts to comply with regulations. These challenges result from employees with minimal knowledge of Windhoek's water crisis or employees who are resistant to changing their habits. We recommend that the DIWTS require industries to develop an employee-training program on water conservation. This training program should cover four topics: how water is used in company operations, methods for water conservation in the workplace, the importance of water conservation, and the consequences of not following new procedures. To assist with implementing this program, we suggest that the DIWTS develop a template that each industry can customize to their operations. The DIWTS must approve the training program before being enacted.

Recommendations for Improved Community Involvement

5. Create a committee to develop and maintain a new awareness campaign to educate the general population on water saving practices. Our surveys showed that while many employees knew about Windhoek's drought, most did not know about Windhoek's water sources and fewer practiced water saving techniques in their daily lives; knowledge of Windhoek's drought is not enough to instill behavioral change. In conjunction with the City of Windhoek's Water Demand Management branch, we recommend the DIWTS create a committee responsible for developing and maintaining an awareness campaign. This campaign would intend to educate the public on Windhoek's water sources, the water reclamation process, the current water crisis, and water saving techniques. We suggest the committee use radio, newspaper, and newsletter marketing as well as volunteers groups for community-based outreach. We also suggest implementation of an educational curriculum for schools and a mascot and slogan for the campaign.

Recommendations for Future Research

6. Conduct a study on unregulated industries, which are polluting water resources in Windhoek, to understand their current waste disposal practices and water usage. Through our interviews with industrial managers, we found that enforcement of regulations was inconsistent among all industries. Certain industries are not regulated by the city. These industries include formally established industries within the city's industrial sector, industries in the informal settlements, and newly encompassed industries on Windhoek's outskirts. We recommend that the DIWTS or other research partners conduct a representative study on industries that are not currently regulated by the DIWTS for effluent disposal.

This study would consist of different topics concerning unregulated industries with an end goal of implementing and enforcing consistent regulations to all industries in Windhoek.

***7.* Conduct a study on the effectiveness of the newly implemented public awareness committee to determine the success of outreach strategies in decreasing the city's water use and educating citizens on the current water situation.** The DIWTS previously used an awareness campaign targeted toward the general population. The city did not evaluate the campaign's effectiveness and since have discontinued these efforts. In correlation with our recommendation to create a public awareness committee, the awareness outreach strategies this committee develops should be evaluated to determine their efficacy. This research would benefit the development of future campaign strategies by determining the effectiveness of the campaign in educating Windhoek citizens on three topics: water scarcity and drought conditions, water reclamation, and water saving techniques. Additionally, this research would determine the effectiveness of various outreach methods to the city's residents.

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- and the fourteen industrial managers of various Windhoek industries.

CONTRIBUTIONS

All group members participated in the interviewing and scribing elements during the fieldwork stage of our project. This included developing interview questions, conducting interviews, creating interview summaries, and coding interviews.

TIMOTHY DOW

Tim served as one of the contributing authors of the methodology, findings, and recommendation chapters. Being the primary author and editor of the methodology, Tim challenged the group to consider the various approaches to and progress of our project. His ability to think critically about the project from various angles was not only something that the group came to rely on, but also served as a valuable asset in conducting interviews and interpreting the responses. Tim contributed to editing each section of the report, focusing especially on syntax and writing coherence. Throughout the course of the fourteen weeks, Tim's reassuring disposition proved to be invaluable for group development.

GRACE HOWARD

Grace was the driving force in writing many sections of the report, serving as one of the contributing authors of the background, methodology, findings, and recommendations chapters while primarily editing for content and clarity. Being the principal author and editor of the background, Grace consistently pushed the group to refine the scope of the project and develop a greater understanding of its implications. Additionally, Grace organized the technical aspects of the interviewing process and took pictures during our site visits to be used in the report and presentations. The group relied on Grace's aptitude for interpreting thoughts and ideas and transforming them into a coherent framework for our project. Lastly, Grace's steadfast belief in each member of the team fostered a creative and supportive environment that was integral to the team's success.

JAVIER MAZO-NIDO

Javi contributed various sections of writing that are integrated throughout the report, especially into the findings and recommendations chapters. Additionally, Javi performed research involved in the technical aspects of water reclamation and the organization of Windhoek's governmental structure as it relates to industrial water and waste management. Javi continuously pursued knowledge of value for completion of the project, allowing the group to have a deeper level of comprehension than we would have had otherwise. Javi contributed significantly to the technical analysis of industrial interviews. This included code organization and graphical interpretation. Lastly, Javi served as an integral part of the editing process, especially related to passive voice, wordiness, and sentence structure.

SARAH MONTEITH

Sarah led the group's overall direction by creating weekly task lists and schedules for completing the project's objectives. In addition to maintaining the team's organization throughout our IQP experience, Sarah was instrumental in formatting and compiling our report. She wrote significant sections of the paper and was a primary editor for organizational flow and grammar. Sarah also served as the primary author and editor of the introduction chapter. The team relied on Sarah's ability to lead discussions, both internally and in meetings and interviews. Sarah's unyielding passion for the project motivated our group to continuously work long and hard on the project. Lastly, Sarah actively worked to resolve any conflicts we faced in our research.

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LIST OF ACRONYMS

COD: Chemical Oxygen Demand
DEA: Department of Environmental Affairs
DIWTS: Department of Infrastructure, Water & Technical Services
DWA: Department of Water Affairs
EIA: Environmental Impact Assessment
MAWF: Ministry of Agriculture, Water & Forestry
MET: Ministry of Environment & Tourism
MTI: Ministry of Trade & Industry

1. INTRODUCTION

To live people rely on one element: clean water. The basic necessities for human life—a secure food supply and freedom from disease—depend on it. Economic development is also water-dependent. Water permeates our lives and is deeply fixed in our cultures. Unfortunately, many cities and towns in developing nations lack the infrastructure necessary to ensure access to water resources, proper waste management, and adequate drainage systems (Tindale & Sagris, 2014).

Africa hosts some of the most rapidly growing, underdeveloped nations in the world. Inadequate access to safe drinking water is a growing concern for these nations, as rapid urbanization outpaces water provision infrastructure. Access to safe drinking water is further restricted in the continent's densely populated slums (World Health Organization and Unicef, 2012). Between 1990 and 2008, the urban population in Africa without access to safe drinking water doubled from 29 million to 57 million (Mafuta, et al., n.d.).

Within Africa, no country faces this challenge more than Namibia. Because of little rainfall, moderate temperatures, and an extreme rate of evaporation, Namibia experiences one of the most limited water supplies in the sub-Saharan region (Biggs, 2000). The capital city of Windhoek is home to nearly 20 percent of the country's residents. The city lies over 550km away from major water sources located along the northern and southern borders of the country. Windhoek's climate and location limit potable water supply and challenge the city's attempts to meet water demand (Central Intelligence Agency, 2014).

The Namibian national government and the City of Windhoek Department of Infrastructure, Water, and Technical Services (DIWTS) have made various attempts to provide sufficient access to potable water for Windhoek's residents. Along with promoting water conservation to reduce water demand, the city provides water through potable water reclamation. Beginning in 1969, this process has proved to be the most feasible and cost effective for water provision in the city (Lahnsteiner & Lempert, 2007). Although water reclamation meets the minimum demands of Windhoek residents, two factors threaten water supply: population growth and water pollution.

Increased growth of industrial activities and rapid urbanization elevate the level of industrial and domestic pollution in the city's water resources (Theron-Beukes, 2014). Because of increased job opportunity and the potential for economic growth, little has been done to discourage the construction of potentially harmful businesses (Cashman, et al. 2014). As a result, many water and waste intensive industries continue to establish in the catchment areas of Windhoek's dams (Theron-Beukes, 2014). As industries within the city establish and grow, increased water use and waste pollution threaten the city's limited water supply. There is a distinctive need for the DIWTS to have a greater understanding of Windhoek industries' water and waste management practices and their effects on the city's water resources.

This project assisted the City of Windhoek's DIWTS to reduce the pollution of water resources by identifying limitations to compliance and determining strategies for improved enforcement of industrial effluent regulations. To accomplish this goal, we completed the following objectives:

1. Reviewed governmental regulations and industrial best practices concerning industrial waste and water management in Windhoek.
2. Investigated limitations to compliance with city regulations for industrial chemical effluents and water consumption practices.

3. Investigated industrial personnel's knowledge of Windhoek's water provision challenges.

This research helped us provide information to the DIWTS regarding the causes of improper industrial water and waste management. We outlined recommendations to improve enforcement of waste and water regulations, improve industrial compliance to these regulations, and increase community involvement in water conservation. We hope that increased public awareness of Windhoek's water situation and improved industrial compliance to governmental water and waste policies will be effective in conserving water and improving its quality in the region for future generations.

2. BACKGROUND

Windhoek, Namibia faces grave water challenges. Industrial pollution intensifies these challenges. This chapter explains the growing problem of industrial water pollution in Windhoek by examining the following four subjects:

- Challenges to ensuring access to adequate water sources in Windhoek
- Windhoek's increasing water scarcity and current water provision system
- Detrimental effects of urbanization and industrialization on water supply
- Strategies for effective industrial regulation

2.1 Water Provision in Windhoek

Windhoek faces an ongoing challenge with low water supply because the region's aridity and absence of surface water resources. Governmental and private organizations have implemented strategies to provide water to the city, including the construction of dams and a water reclamation system. The city's growing demand for water puts pressure on the current water supply and infrastructure.

WATER SOURCES. Namibia's geography and climate inhibit the availability of water resources. The country experiences most rainfall during the rainy season, which occurs from December to March (Biggs, 2000). Rainfall is not evenly distributed throughout the country [see *Figure 1*]; coastal and southern regions receive less rainfall than northern and eastern regions.

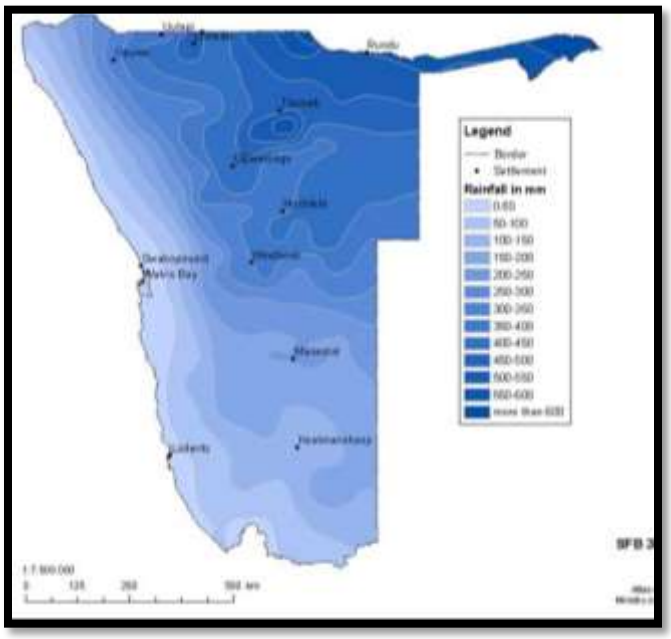

FIGURE 1: THE GEOGRAPHIC RAINFALL TRENDS IN NAMIBIA (CIA, 2014)

With only three major perennial rivers located on the northern and southern borders of the country, the majority of the country's residents do not have access to year-round surface water storage (Hyens, 2004) [see *Figure 2*]. The 380,000 residents living in centrally located capital of

Windhoek experience this reality. The city receives an average of 200-300mm of rainfall per year (CIA, 2014).

FIGURE 2: NAMIBIA'S PERENNIAL RIVERS (MAPS OF WORLD, 2014)
DISTANCES FROM WINDHOEK: 550KM (OKAVANGO), 600KM (ORANGE) & 630KM (KUNENE)

Windhoek relies on the ephemeral rivers that exist during the summer months when rainfall occurs intermittently (Frenken, 2005). For the rest of the year, the city depends on borehole access to underground water sources.

Water scarcity has not always been a challenge for Windhoek. The city was founded in 1890 because copious amounts of water existed naturally in underground springs (Hyens, 2004). The abundance of this resource attracted many people. By the 1930s, this groundwater supply was no longer adequate for the population: the demand for water surpassed the natural water supply (du Pisani, 2004). Located over 550 km from the closest perennial river, Windhoek has continuously faced challenges with sufficient water provision and sustainability. Today, these challenges are more pertinent than ever.

WATER PROVISION INFRASTRUCTURE. Windhoek's recent history includes a series of attempts to quench the thirst of the growing population. Windhoek constructed its first dam in 1933. Since then, dams serve a crucial role in supplying water to the city. In addition to the Avis Dam and other smaller dams within the city boundaries, Windhoek obtains its water from a three dam system [see *Figure 3*].

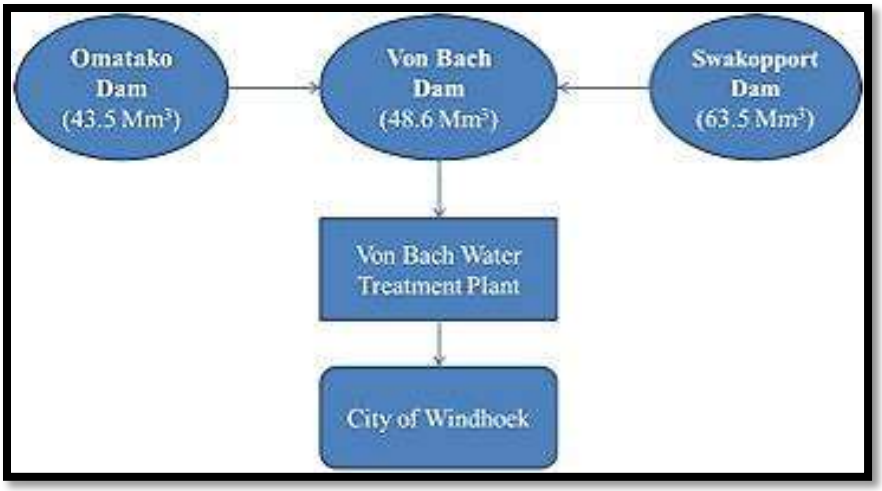

FIGURE 3: THREE DAM SYSTEM CONFIGURATION

Water capacities vary throughout the year, but dams provide a solution to water loss from the high evaporation rate (Lahnsteiner & Lempert, 2007). The system is designed to supply approximately 20 Mm^3 of water per year to Windhoek (du Pisani, 2004). As drought continues to plague the region, dam inflow decreases, threatening the supply. Current drought conditions place the three dams at their lowest levels since 2011. Namibia's third largest reservoir, the Swakopport Dam, is 34.8 percent full, while the Von Bach Dam and Omatako Dam stand at 35.7 percent and 6.6 percent respectively (The Namibian, 2015). The combination of limited inflow and increasing water demand requires further augmentation of the system for long-term, sustainable solutions.

There are three main organizations responsible for delivering sufficient and quality water to the city of Windhoek:

- **Department of Infrastructure, Water, and Technical Services (DIWTS).** The department oversees the collection, treatment, quality assurance, and regulation of the city's wastewater through maintaining and improving sewage infrastructure (Theron-Beukes, 2014). The DIWTS works with the Department of Water Affairs and the National Development Corporation to explore, develop, and execute projects related to the city's water systems (Hyens, 2004).
- **Namibia Water Corporation Ltd (NamWater).** NamWater is a commercial company responsible for reliably providing bulk water to industries at the lowest possible price (NamWater, 2015). The institution provides over 70 percent of Windhoek's water supply. (Hyens, 2004). NamWater also works with the Directorate of Rural Water Supply and the Ministry of Agriculture, Water and Forestry to supply water to the rural communities in Namibia (NamWater, 2015).
- **The Windhoek Goreangab Operating Company Ltd (WINGOC).** The WINGOC is comprised of three major international water treatment contractors in direct partnership with the city of Windhoek (Lahnsteiner & Lempert, 2007). Established primarily to operate the New Goreangab Water Reclamation Plant, the organization supplies reclaimed water to the Windhoek's residents (Hyens, 2004).

In total, these organizations spend eight times more on water provision for citizens than any other sub-Saharan country each year (Schlechter, 2014). These efforts resulted in various types of

water provision infrastructure, including the development of dams, pipelines, and water treatment facilities.

WATER DEMAND. Managing water demand is equally as important as managing the country's limited water sources. After Namibia's independence in 1990, Windhoek experienced a shift from farming and agricultural sectors to a focus on manufacturing and production of goods. This shift intensifies the impacts of industrialization (Merriam-Webster, 2015). Industrialization benefits the economy but increases the demand for water. Windhoek continues to experience population growth in the urban area and informal settlements. The city's population currently grows at an annual rate of 4.4 percent (WHO, 2014). Since 2000, economic and population growth have increased the water demand from 57,000 m^3 to as much as 100,000 m^3 per day (Lahnsteiner & Lempert, 2007).

Windhoek has made progress in reducing water demand. As the city became more populated in the late 1990s, local government implemented various programs to reduce the growing demand. These programs succeeded in reducing the daily per capita water use from 328 to 180 L (Brinkman, Ludwig & Nikitina, 2010). While this per capita daily water use is expected to remain relatively constant (Lahnsteiner & Lempert, 2007), Windhoek's urban planning department predicts that the city's total water demand will continue to grow. The department projected that the city population will increase at a rate of 4.05 percent in predicting water consumption demands from 1970 to 2040 (Brinkman, Ludwig & Nikitina, 2010) [see *Figure 4*]. Despite these improvements, water demand continues to rise in Windhoek. Rapid increases in water demand are difficult to address because of the decreasing water supply.

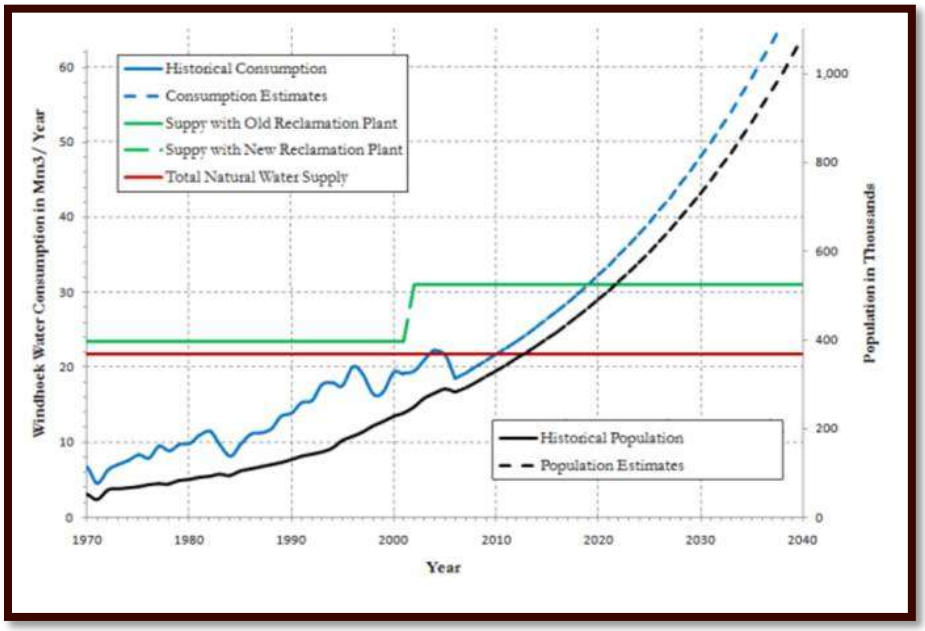

FIGURE 4: WATER SUPPLY, DEMAND, AND PROJECTIONS FOR WINDHOEK NAMIBIA THROUGH 2040 (BRINKMAN, LUDWIG & NIKITINA, 2010)

WATER RECLAMATION. Windhoek pioneered water reclamation globally in 1969 as a solution to the difficulties posed by securing water sources over long distances. This process has since become an integral strategy for supplying Windhoek with a reliable water supply. Since its implementation, cities around the world have adopted similar processes to meet the increasing demand for water (Monks, 2014). The water reclamation process in Windhoek involves treating wastewater and recycling back to the city's domestic water supply.

Windhoek uses two types of recycled water. The first type of water reclamation is called non-potable reuse. This process involves treating industrial wastewater to a purified standard that is used for applications such as irrigation, toilet water, or industrial use (Environmental Protection Agency, n.d.). The second type of reclamation process is direct potable reuse. This reclamation process involves more advanced domestic wastewater treatment so that recycled water can meet drinking water standards and be put into the tap water supply (du Pisani, 2004). This technology is essential for the city of Windhoek to meet the demand for water. *Figure 5* offers a visual depiction of Windhoek's water reclamation.

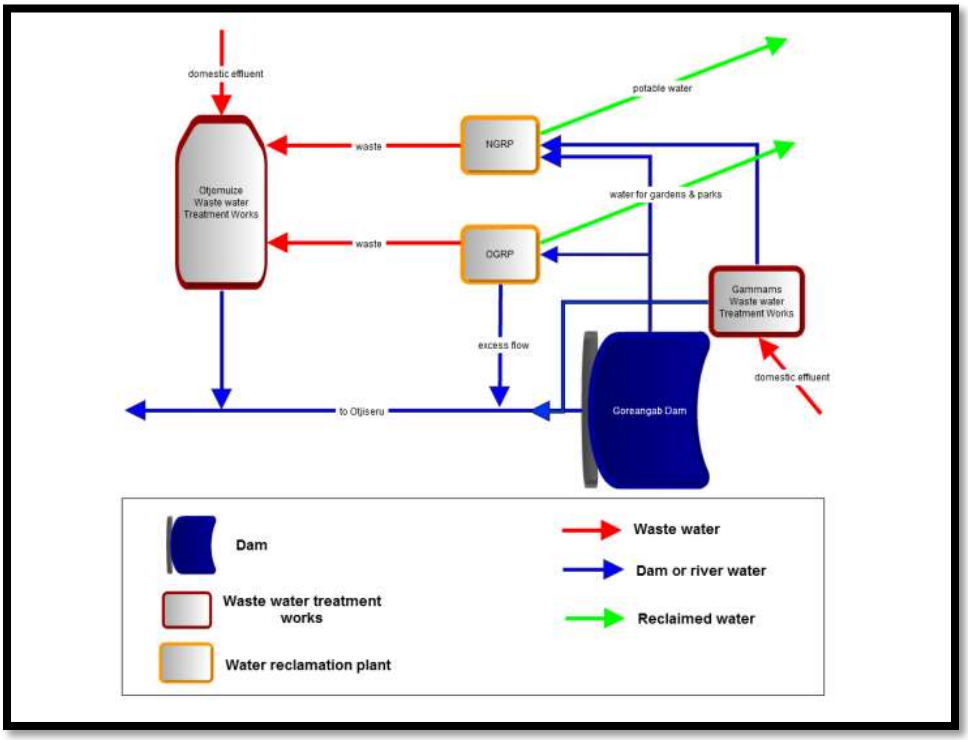

FIGURE 5: FLOWCHART OF WINDHOEK'S WATER TREATMENT AND RECLAMATION PLANTS (BRINKMAN, ET. AL, 2010)

When the city implemented the reclamation process, treated domestic wastewater from the Gammams Water Care Works was blended with water from the Goreangab Dam to increase supply and dilute concentrations of influent water constituents. The original reclamation plant, now referred to as the Old Goreangab Water Reclamation Plant, supplied about 30 percent of water supply when first established. Numerous upgrades to infrastructure brought the plant's capacity from 1.7 Mm^3 per year to 2.7 Mm^3 per year (du Pisani, 2004). The growing demand for water still outpaced the plant's capabilities. Thus in 2002, the city constructed an additional water reclamation plant, called the New Goreangab Water Reclamation Plant (NGWRP). The plant

provided the city with a larger capacity of 7.6 Mm^3 per year, supplying about 35 percent of the city's water (Lahnsteiner & Lempert, 2007). Without water reclamation, the demand for water would exceed the available supply.

2.2 Sources of Water Pollution

The greatest threat to Windhoek's reclamation process is pollution from the city's industries and residential activities. *Table 1* shows the two types of pollution straining Windhoek's water sources:

TABLE 1: POINT SOURCE VS. NON-POINT SOURCE POLLUTION (THERON-BEUKES, 2014)

Type of pollution	Origin	Quantity	Transport	Application in Windhoek
Point Source	Singular, identifiable location	Large quantity emitted from single location	Directly to a water body, drain, or treatment facility	Industrial Effluent Discharge
Non-point Source	Many untraceable sources over a given area	Small amounts emitted from many locations	Rainfall runoff to water sources	Anthropogenic Sources

Windhoek's water treatment facilities cannot manage the influx of increasing pollution.

INDUSTRIAL POLLUTION. Industrial effluents pollute Windhoek's water resources. Manufacturing companies, the main industry sector in Windhoek, transform raw materials into useable products. The main manufacturing sectors in Windhoek include (Theron-Beukes, 2014):

- Food Products
- Beverage Products
- Paint
- Panel Beating
- Chemicals

The processes used to manufacture these products often require water for cooling, steam generation, cleaning, and sanitation purposes (The Organisation for Economic Co-Operation and Development , n.d.). These processes produce effluents that are harmful to the environment, human health, and the reclamation process [see *Figure 6*].

FIGURE 6: SAMPLES OF WINDHOEK INDUSTRIAL EFFLUENTS

Regulatory agencies measure the concentration of four major components used to calculate industrial effluent charges. The effects of these components on the quality of drinking water, the environment, and the water reclamation system are discussed below:

- **Ammonia.** The environmental forms of ammonia originate from metabolic, agricultural, industrial processes, and disinfection with chloramine (WHO, 2003). The natural ammonia levels in ground and surface water are below 0.2ppm, though in anaerobic environments, this can reach 3ppm. Elevated ammonia levels in water can be indicative of possible bacterial, sewage, or animal waste pollution. Ammonia in drinking water does not have immediate health effects, and thus no heath-based guideline level is proposed (WHO, 2003). Despite this, ammonia compromises the efficiency of water disinfection, causes nitrate formation in distribution systems, results in failure of filters for the manganese removal, and negatively impacts water's taste and odor (WHO, 2003). Thus, the concentration of ammonia is an important consideration within the water reclamation process.
- **Phosphates.** Natural phosphate levels in ground and surface water are about 0.2ppm. Elevated phosphate levels can result from human sewage, agricultural run-off, sewage from animal feedlots, pulp and paper industry effluent, and chemical manufacturing (USEPA, 2012). Excess phosphates in water can result in an increased level of algae and plant growth, both depleting oxygen from water. Phosphates in drinking water do not have immediate health effects, and thus no heath-based guideline exists (USEPA, 2012). When phosphate concentrations rise above 100ppm, the coagulation processes in water reclamation are adversely affected.
- **Chemical oxygen demand.** Chemical oxygen demand (COD) is a laboratory test often used to measure organic constituents in wastewater and treated effluent. The most common sources of COD in industrial effluent are residual food waste, antifreeze, and emulsified oils. High COD levels in drinking water have adverse environmental effects, including toxic algae blooms and bacteria from organic waste. Low dissolved oxygen (less than 3ppm), or hypoxia, causes reduced cell functioning, disrupts circulatory fluid balance, and can result in death of aquatic species. Hypoxic environments can also release pollutants stored in sediment (StormwateRx, 2010). The effect on the environment is an important consideration when treating industrial effluent through reclamation. While high COD levels have implications within the environment, there are no cited effects of COD on human health.
- **Suspended Solids.** Suspended solids in water are generally measured as part of the total dissolved solids, which together include components such as clay, algae, nitrate, phosphorous, iron, sulfur, etc. Total solid measurements are useful for indicating the effects of industrial discharges, sewage, fertilizers, and runoff (USEPA, 2012). High levels of suspended solids may have adverse health effects, especially for people who are not accustomed to the water in the region (USEPA, 2012). Additionally, high solid concentrations decrease the amount of light that passes through the water, slowing photosynthesis in aquatic plants. Suspended solids can also serve as carriers of toxins, and thus high levels pose a severe threat to the environment and drinking water quality (USEPA, 2012). High dissolved solid levels reduce the efficiency of water reclamation plants and the operations of industrial processes that use raw water. High levels of suspended solids adversely affect the taste and clarity of drinking water. Solid concentrations are very important measurements in areas where discharges from wastewater treatment plants occur ("Water Resource Management Act", 2012).

Industries use varying techniques for effluent treatment depending on the manufacturing process and effluent content [see *Figure 7*].

FIGURE 7: EFFLUENT TREATMENT TECHNOLOGIES

Each water reclamation plant has maximum parameters for treatment of ammonia, phosphate, COD, and suspended solids. The Ujams Reclamation Treatment Plant treats effluents from nearly all industries in Windhoek. *Table 2* compares the treatment capacity of the Ujams reclamation plant to the average concentrations found in Windhoek industries' effluent samples.

TABLE 2: UJAMS DESIGN CONCENTRATIONS & AVERAGE EFFLUENT LEVELS

Constituent	Design Concentration (mg/L)	Average Effluent Level (mg/L)
Ammonia	96	53
Phosphates	25	12
COD	3314	8936
Suspended Solids	1132	2232

Many industrial effluent concentrations exceed the treatment capacity. This also contributes to a decline of water quality, posing an additional threat to human health and environmental stability.

FIGURE 8: TREATED WATER LEAVING THE UJAMS RECLAMATION PLANT

Figure 8 shows reclaimed water leaving the Ujams, where it is used only for irrigation purposes in the city. The Ujams Reclamation Plant was only designed to treat a set volume. Increased industrialization has caused this volume to be exceeded, causing overflow. Ujams operators discharge this overflow directly into the Klein River after minimal treatment. During the rainy season, this overflow travels 300km to the Swakopport Dam. Water from the Swakopport dam travels to the Von Bach Dam where it is used for the city's drinking water. *Figure 9* provides a visual depiction of this process:

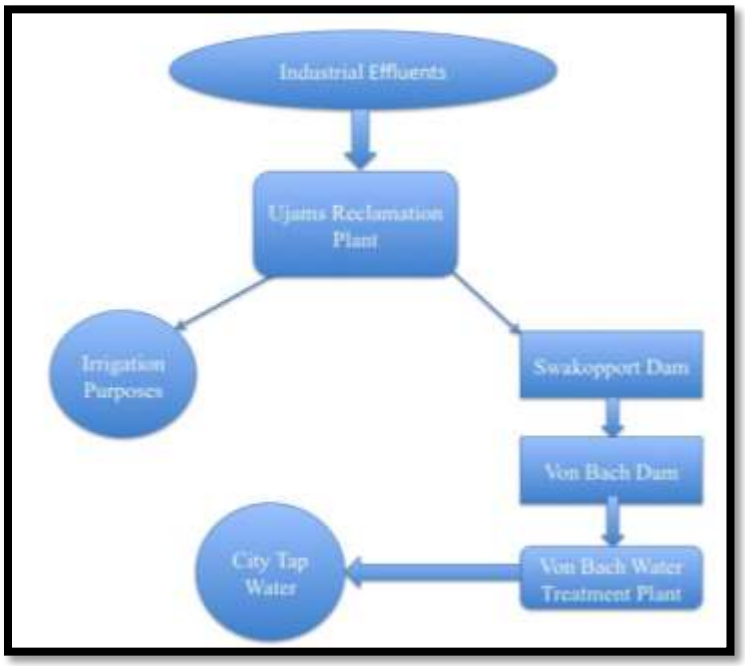

FIGURE 9: INDUSTRIAL EFFLUENT FLOW CHART

When industrial effluent concentrations and volume exceed the plant's design parameters, the treatment process becomes less effective. As a result, the water leaving the plant is of a poorer quality than it would be otherwise. Industrial effluent management processes are integral to the optimal operation of the water reclamation system.

DOMESTIC POLLUTION. Domestic pollution originates from residential locations. Population growth in Windhoek has pushed people into Katutura, one of Windhoek's informal settlements (Faes, 2013). Katutura is located in the catchment of the Goreangab Dam, and during periods of rainfall, runoff washes the contaminants from the settlement into the dam without treatment. With a population growth rate higher than the formalized city, overcrowding in Katutura has created an unsanitary environment. Katutura lacks access to clean toilets, which causes citizens to practice open defecation. When toilets are available, one will serve an estimated 200 people (Law, 2014). Some residents run car washes and openly slaughter animals for meat. The combination of these conditions paired with the settlement's lack of proper drainage infrastructure creates major problems during Namibia's rainy season. Although the dam is 100.2 percent full, water in the Goreangab Dam is unusable due to severe pollution (The Namibian, 2015).

2.3 Obstacles to Minimizing Water Pollution

The city residents lack knowledge about the city's water challenges contribute to minimal personal responsibility to save water. Waste and water management regulations lack effective enforcement caused by overlapping government responsibilities and expanding city boundaries. These considerations challenge the city to strategically minimize water pollution.

LOW GENERAL POPULATION KNOWLEDGE. Low general population knowledge of water scarcity in Windhoek is an obstacle to reducing pollution and water consumption. As John P. Knotter, a professor at the Harvard Business School wrote, "Before you get buy-in, people need to feel the problem" (2011). Many Windhoek residents are not aware of the water reclamation process is and lack the feeling of accountability needed to instill change (Lahnsteiner & Lempert, 2007). Forty-three percent of those with higher education and 53 percent of those with less education believe that the water is of "good" quality (Boucher, Jackson, Mendoza & Snyder, n.d.). With only half the population citing a threat to water quality, knowledge gaps directly correlate to how residents manage their water and waste (Theron-Beukes, 2014).

POOR INDUSTRIAL WASTE & WATER MANAGEMENT. Poor industrial waste and water management contributes to the water pollution problem in Windhoek. The proximity to a high concentration of consumers and employees attracts industries to establish in Windhoek. Likewise, government supports industrialization in Windhoek due to the valuable commodities and employment, which they provide. The government continues to allow water and pollutant intensive industries to build and operate in the city. Three national ministries and one local authority (the DIWTS) are responsible for enacting industrial water and waste management regulations in Windhoek and surrounding areas (Hyens, 2014). Duties of these authorities tend to overlap, complicating regulatory enforcement.

2.4 Best Practices for Industrial Regulation

Developing countries often face challenges establishing effective regulatory processes for managing industries. As one case study describes, "conventional command-and-control environmental regulation often performs poorly in developing countries" (Blackman, Lahiri, Pizer, Planter & Piña, 2007). This phenomenon occurs because the country's governmental regulatory infrastructure takes time to develop. Developing countries can create effective regulations if best practices are followed. This section discusses case studies regarding best practices for regulating industries.

VOLUNTARY COMPLIANCE PROGRAM. One method for industrial regulation is voluntary compliance. Because the developing nation Mexico lacks "manpower, expertise and political will" to put regulatory pressure on industries, the governmental Ministry of Economics and the Ministry of Environment implemented a voluntary program in 1992 titled the Clean Industry Program. Below are a few key elements of the program (Blackman et. al, 2007):

- **Audits.** Participating companies are required to hire a third party auditor once every three years to evaluate the company's environmental performance to both industrial regulations and best practices. After the evaluations, the auditors help company managers develop an action plan to improve processes that are not environmentally sustainable.
- **Clean Industry Certificates.** Once the company completes the action plan developed with the auditor and improves their environmental deficiencies, the city awards the company a "Clean Industry Certificate". These certificates are valid for the following three years until another audit is due. These certificates have become a major marketing strategy.
- **Citizen Complaints.** If the government receives a complaint from a citizen about the company, the company will have to initiate an audit even if the three years have not expired.
- **Accidents**. If the company experiences an accident such as a chemical spill, the company will have to initiate an audit, even if three years have not expired.

In considering limitations of a voluntary compliance based program, evidence shows that this type of program tends to draw companies to participate who are already environmentally friendly or in compliance with regulations. A study performed on 114,000 companies in Mexico revealed that industries were three times more likely to join the program after issued an environmental regulation fine. The study also showed that companies who exported internationally were 1.8 times more likely to join the program. Companies who imported internationally were 1.7 times more likely, and companies who sold products or services to the government were 1.4 times more likely to participate than those who did not. Participation from industries grew from 78 to 7,616 companies in the first 16 years of the Clean Industry Program's operation (Blackman et. al, 2007).

PUNISHMENT PAIRED WITH COOPERATION. An additional method of industrial regulation comes from a study on the effectiveness of the United States' Occupational Safety and Health Administration's (OSHA) regulation enforcement. The study focuses on punishment and cooperation. Effective regulators should not question whether to use punishment or cooperation, but rather, when and how to use these together (Shapiro & Rabinowitz, 1997). The article describes the general incentives for industries to comply, outlined below (Shapiro & Rabinowitz, 1997):

- Cost of fines (short-term incentive)
- Maintaining low prices for services or products (long-term incentive)
- Maintaining a good reputation (long-term incentive)

When company managers have negative attitudes towards regulators, cooperation and communication decrease when new standards arise (Shapiro & Rabinowitz, 1997). *Figure 10* explains common challenges that arise when regulators impose violations on companies.

FIGURE 10: CHALLENGES TO REGULATION ENFORCEMENT (SHAPIRO & RABINOWITZ, 1997)

Effective regulation can be achieved through a number of strategies. These strategies include:

- Cooperation
- Regulator Roles
- Strategic Violations
- Communication

Cooperation. Cooperation between regulators and industrial management is crucial for an effective regulatory environment. The most effective regulators follow an enforcement process, which is neither solely cooperative nor solely punitive. The key is for regulators to strike this balance. Cooperative attitudes stem from:

- Enforcing larger, more serious violations rather than smaller ones
- Issuing non-monetary warnings before fines for smaller violations

Using these strategies can improve the cooperation between industries and regulators (Shapiro & Rabinowitz, 1997).

Regulator Roles. The case study describes a strategy in which regulators can take on a variety of roles in their enforcement:

- **Aggressive Enforcer.** This role is appropriate to use with industries that actively attempt to only comply with regulations they will get caught violating. In this role, the regulator would issue heavy fines and violations to these companies.
- **Persuasive Politician.** This role is appropriate to use with industries that view regulations as unreasonable. The regulator would explain the reasoning for the regulations and explain how compliance can be attained.
- **Informative Consultant.** This role is appropriate to use with industries that do not understand the regulations or how they are violating them. This regulator would explain the regulations and the violations.

Effective enforcement involves training regulators about each role and using discretion to determine which role to use for each industry (Shapiro & Rabinowitz, 1997).

Strategic Violations. This strategy is most effective for targeting the most serious violations and the most adamant violators. Regulators should take caution in issuing aggressive penalties for smaller violations due to increased risk of the situations in *Figure 10*. It is key to impose similar violations on non-complying companies *and their competitors*. Companies are less likely to comply with regulations if regulators are not enforcing the same regulations on their competitors.

Communication. Communication is a strategic component for effective industrial regulations. As Shapiro & Rabinowitz state in their case study about OSHA regulators, "Employers may be more willing to cooperate with OSHA if they better understood the purpose and necessary compliance requirements of OSHA's rules" (1997). Many industries do not comply with regulations the documents are complex. Because of this, it is beneficial for regulators to simplify and explain the regulations to avoid accidental violations.

LESSONS LEARNED. Case studies are beneficial to research for examining practices used in other parts of the world. The case studies in this section provided the following lessons in considering effective industrial regulation:

1. A voluntary compliance program may be applicable in Windhoek as the population continues to develop a greater understanding of the city's water crisis. Many industries may desire to have a clean industry certification as a marketing strategy to consumers.
2. City regulators can adapt effective cooperation & punishment practices such as increased communication and discretionary use of regulatory roles.

These lessons and others are important when evaluating the effectiveness of the regulatory environment in Windhoek, Namibia.

3 METHODOLOGY

The goal of this project was to assist the City of Windhoek's DIWTS to reduce the pollution of water resources by identifying limitations to compliance and determining strategies for improved enforcement of industrial effluent regulations. To accomplish this goal, we pursued three our objectives were as follows:

1. Review governmental regulations concerning industrial waste and water management and identify inefficiencies within the regulatory system.
2. Investigate limitations to compliance with city regulations for industrial chemical effluents and water consumption practices.
3. Investigate industrial personnel's knowledge of Windhoek's water provision challenges.

In this chapter, we describe the approaches our team developed to gather and analyze input from credible experts, key industrial stakeholders, and industrial employees. Additionally, we discuss how we utilized the results to develop recommendations for pertinent organizations.

Objective 1: Review governmental regulations concerning industrial waste and water management and identify inefficiencies within the regulatory system.

DESIRED KNOWLEDGE. To understand each organization's roles in the regulation and certification of industries and the nature of Windhoek's regulatory environment, we interviewed representatives from three regulatory agencies. Below is a list of these agencies and the information we discussed during our visits:

1. **Department of Infrastructure Water and Technical Services (DIWTS).** The current city regulations for industrial water use and effluent disposal, enforcement process for these regulations, current water reclamation and treatment processes, and Windhoek industries water consumption and effluent production records.
2. **Department of Water Affairs (DWA).** The current water issues Windhoek is facing, city drainage and water consumption, and the flaws in the regulation process.
3. **Department of Environmental Affairs (DEA).** Effluent effects on human health, the environment, and the water reclamation process.

METHOD. Representatives from the DIWTS suggested we interview members from the DWA and DEA. We developed different interview questions for representatives from each organization [see *Appendix A*]. We conducted interviews with these experts using a facilitator to ask questions, a scribe to record notes, and two members to voice record the conversation if the interviewee approved. We spoke with two DITWS staff members, Lorraine !Gaoses and Salatiel Kalimbo. Lorraine is the pollution control engineer for the DIWTS and Kalimbo is the pollution control inspector. Both Lorraine and Kalimbo specialize in water pollution and waste and water management of Windhoek industries. They supplied us with reports on industries' water consumption and effluent production, city drainage regulations, and potential citywide water saving methods. The DIWTS also arranged for us to tour the city's water reclamation and treatment plants. During our visits, we spoke with plant managers about the plant processes and operational challenges [see *Appendix E*]. We interviewed two hydrologists from the DWA, Matthew Hambabi and Ivondia Karumendu. They answered our questions in great depth using

their extensive knowledge of the country's water sources and national industrial regulations. We also interviewed the Environmental Commissioner of the DEA, Teofilus Nghitila. His knowledge and insight on the cities pollution issues and regulations helped inform our research. Each organization's members all allowed us to ask questions throughout our time in Windhoek.

METHOD JUSTIFICATION. We interviewed these governmental representatives to understand the regulatory process before speaking with industrial managers. We chose interviewing as our method to complete this objective because it was most feasible. Our sponsors supported this method most when we discussed strategies of acquiring our desired information. Stationed at the DIWTS, Lorraine and Kalimbo were readily available to answer our questions in person. Similarly, the DIWTS is located in close proximity to the DWA and DEA, and thus we could feasibly visit these organizations. With our limited timeframe in Windhoek, we needed to acquire information as quickly as possible and interviews provided an effective platform to achieve this. Personal interactions are more effective than communication through media. Interviewing also allowed us to ask follow-up questions when we did not understand a topic presented to us.

ANALYSIS METHOD. We used the recordings and written notes to summarize the interviews with the DIWTS, DEA, and DWA [see *Appendix B, C, D*]. We used these summaries for two purposes:

1. To understand each organizations' responsibilities and measures they take when an industry violates regulations;
2. To create a flowchart to display each organizations' responsibilities and identify areas where communication can improve in the regulatory process [see *Appendix F*].

LIMITATIONS. We identified governmental representatives' inflexibility or unwillingness to participate as a limitation to our method. To address this concern, representatives from the DIWTS contacted the DEA and DWA on our behalf, enabling us to interview the department representatives in a suitable timeframe. By considerately introducing our project and goals for the interview, we provided the interviewee with a clear purpose for requesting an interview, and all interviewees were willing to participate [see *Appendix G*]. We anticipated that not all representatives would be comfortable with recording our conversation. To address this, we informed them that all information would be used solely for furthering our research. We additionally gave them the opportunity to decline to answer any question or stop the recording at any time.

Objective 2: Investigate limitations to compliance with city regulations for industrial chemical effluents and water consumption practices.

DESIRED KNOWLEDGE. We interviewed industrial managers from eleven different industries to understand the following topics:

- **Current Practices:** Methods the industry practices for managing water use and effluent disposal. Procedures for recording waste content and quantity. Effluent treatment procedures prior to disposal.
- **Water Monitoring:** How water usage is recorded.

- **Knowledge Regulations/Best Practices:** Managerial knowledge of city regulations for effluent drainage. Managerial knowledge of best practices locally or globally for water conservation and effluent treatment.
- **Challenges:** Challenges managers encounter as the company attempts to meet regulations, save water, and manage effluents.
- **Motives:** Motivation for efforts to comply with city regulations.
- **Employee Training:** If and how employees are advised to conserve water in the workplace.
- **Additional Support:** Assistance the city can provide industries to aid managerial staff in efficient water use and management.

METHOD. To obtain this information, we followed six methods: select industries to visit; contact industrial managers; prepare interview questions; conduct on-site interviews with managers; summarize the interview; and analyze the responses. The DIWTS provided us with information about various manufacturing industries within the city. This information outlined the industries that exhibit exemplary water usage and effluent disposal and those which consume large quantities of water and exceed effluent parameters. Together with the DIWTS, we selected eleven industries to research. *Table 3* displays the profiles for each industry.

TABLE 3: SELECTED INDUSTRIES CATEGORIZED BY COMPANY NAME, TYPE OF INDUSTRY, AND COMPLIANCE STATUS

Company	Product/Service	Market	# Employees
Company A	Beverage	International	550
Company B	Dairy	Local	700
Company C	Meat	Local	400
Company D	Abattoir	International	1,000
Company E	Meat	Local	750
Company F	Paint	International	-
Company G	Panel Beating	International	100
Company H	Chemicals	Local	20
Company I	Panel Beating	Local	10
Company J	Feedlot	Local	65
Company K	Tannery	International	50

With support from the DIWTS, we contacted each company by phone to establish interviews with operational managers. When preparing for and conducting our interviews, we completed the following tasks:

- Establish a plan for interview and desired information prior to established (Cohen & Crabtree, 2006)
- Explain the reasoning behind research and capture interest of the interviewee (Rowley, 2012)
- Center research objectives around experiences, opinions, attitudes, values, and processes (Rowley, 2012)
- Ask questions that are both theoretical and pragmatic (Rowley, 2012)
- Summarize interviews for details

During our interviews, we followed a consistent format, which included opening with a predetermined introduction, signing a consent form, and asking designated interview questions

[see *Appendix H*]. A scribe recorded pertinent information within the categories previously outlined. After each interview, the scribe used the notes and recording to create a thorough summary [see *Appendix I-S*]. Because the city does not regulate informal industries, we modified the questions when interviewing an informal industry owner in Katutura. In this interview, we posed questions about challenges the company faces using water and disposing waste [see *Appendix T*].

METHOD JUSTIFICATION. We selected the eleven industries based on their compliance status, degree of regulation, and DIWTS recommendation. Within industries, operational managers are the most knowledgeable employees on waste and water management practices. We selected them as interviewees because they are experts on these topics. We modeled our interview process from best practices for unstructured interviews. We chose to interview managers because many industries are local and easily accessible. Interviewing helped us acquire information in a specified timeframe. We summarized each interview due to time constraints that inhibited full interview transcribing. Summarizing the interviews allowed us to focus on pertinent information that managers spoke about. The methods we developed, in combination with our analysis method, allowed us to uncover the most common and significant responses.

ANALYSIS METHOD. We analyzed responses from interviews using a coding system. We modeled this process from the following best practices:

- Summarize interviews and analyze the content for patterns (Hubbard & Power, 1999)
- Identify common themes amongst responses of the same topic (The University of Texas at Austin, 2011)
- Identify how interviewee's experiences and roles correspond to their responses The University of Texas at Austin, 2011)

Coding has been successful for researchers used to quantify qualitative data making the information more understandable. We used coding as an analysis strategy to categorize responses and simplify large amounts qualitative data collected in our interviews. We sorted codes into the following categories:

- Motives for Regulatory Compliance
- Additional Support for Compliance
- Challenges for Regulatory Compliance
- Challenges for Water Use & Management
- City Interaction with Industries
- Industrial Comments on Regulations
- Company Background
- Industrial Effluent Treatment
- Future Efforts
- Employee Training
- Water Saving Measures

We highlighted significant responses from the interview summaries and created codes for those responses [see *Appendix U*]. These codes then allowed use to compare the thoughts of managers from all industries we visited and quantify similar responses. We identified the trends in responses from industrial managers on the categories of interest [see *Appendix V*].

LIMITATIONS. We anticipated challenges with uncooperative participation for interviews. To address this, we began each interview by considerately describing our project. We also stated that the purpose of the interview was to help industries achieve compliance through support from the DIWTS. Additionally, not every interviewee allowed us to record the conversation, causing us to consider human error in accuracy of our notes. Even when able to record interviews, we encountered language and accent barriers. To overcome this limitation, Kalimbo served as a liaison to help with difficulties during interviews. The sample size and characteristics of companies also limited the accuracy of our findings. While we investigated a variety of manufacturing companies, the overall number was limited due to the time constraints. Many industries in Windhoek are not regulated by the city or are complying with regulations. These industries were not well represented in our sample. As a result, our data could be skewed towards only companies that lack the ability to comply with regulations.

Objective 3: Investigate industrial personnel knowledge of Windhoek's water provision challenges.

DESIRED KNOWLEDGE. We investigated the knowledge of industrial personnel to understand their views of water use and waste management in the city of Windhoek. Topics of interest included:

- **Personnel Perceptions:** How industrial employees perceive water and effluent management and how those perceptions impact their actions within the workplace and a personal setting.
- **Drought Knowledge:** How knowledgeable and aware industrial employees are of the current drought in Windhoek.
- **Personal Practices:** If industrial employees practice water saving efforts in their workplace or household.
- **Alternative Solution Perceptions:** If industrial employees support potential measures the government may implement to conserve water in emergency situations.

METHOD. To obtain this information we followed three methods: develop survey content; deliver surveys to industrial managers for distribution; and collect and compile responses. We developed surveys to acquire specific information from industrial employees [see *Appendix W*]. Before our site visits, we contacted the operational managers and confirmed that surveys could be administered at their workplace. During our interviews, we gave surveys to operational managers for them to distribute to production employees. We gave each industry one week to have employees complete the survey. During collection, we spoke with the managers about the method they used to distribute the surveys. We designed the surveys to be applicable for all employees within the industry and ensured that their answers remain confidential. To accommodate the manufacturing schedule at Company E, we administered surveys directly to employees.

METHOD JUSTIFICATION. We developed surveys with the purpose of helping the DIWTS understand how knowledgeable industrial employees are on the water crisis in Windhoek and what water saving measures they practice in their personal and work lives. This method allowed us to effectively reach larger populations than interviewing would have allowed. We modeled the surveys using the following best practices (Oracle, 2012):

- Write relevant questions that are short and clear
- Use simple and precise language
- Develop response options cautiously, considering order of responses and potential biases

Additionally, we drew upon challenges that DIWTS representatives described in past survey administration to improve the design and content of our surveys. We identified the lack of participation in open-ended questions to be a limitation. To address this, we designed all questions on the survey to be either multiple-choice or of gradient style. Due to the setting in which managers distributed the surveys we chose paper surveys to be the most feasible medium.

ANALYSIS METHOD. We compiled all responses from the surveys into a spreadsheet and used this to develop graphical representations of the information [see *Appendix X*]. These graphs allowed us to identify knowledge gaps among industrial employees. They also enabled us to recognize any differences in accountability between industrial managers and production employees. Lastly, survey collection allowed the DIWTS to assess the effectiveness of their previous awareness campaign and tailor a new campaign to address the knowledge gaps of the Windhoek citizens.

LIMITATIONS. The most effective way to collect representative employee data was to administer the surveys ourselves at each industry. However, managers expressed two major concerns with this process:

- The production floor was an unsafe environment to administer surveys.
- The production floor needed to remain sterilized and is therefore not a suitable location to administer surveys.

The only option we had to distribute the surveys was to leave them with the industrial manager. Though we lacked the ability to control the size and diversity of the sample population, we attempted to mitigate this by instructing managers on optimal survey distribution. The integrity of survey responses was limited in two ways: the inability for employees to ask questions and the honesty of their answers. Surveys in English and Afrikaans were provided to address potential language barriers and minimize content related questions. The survey did not contain questions regarding sensitive information, curbing influences to answer dishonestly. Additionally, the accuracy of our survey results was limited by sample size. Many companies we visited had hundreds of employees. We distributed 30 surveys at each company. This number was more representative of the employees in a company with a staff of 50 versus a staff of 1,000. Out of eleven industries, we obtained data from seven of them. We visited Company J and Company K with limited time before our project completion date, and thus were not able to distribute surveys. Additionally, two companies never returned the surveys.

4 FINDINGS

The results of our research are presented in this chapter. Using evidence from interviews with regulatory personnel and industry operational managers as well as employee surveys, we explore the implications of the results.

Finding 1: The complexity of regulatory agency responsibilities and the inconsequential nature of the legislation they enforce contribute to ineffective enforcement of industrial regulations.

SUMMARY OF EVIDENCE. Three national organizations and one local organization are responsible for the regulation of industrial waste disposal and water consumption. These agencies are interrelated and overlap in their regulatory responsibilities as outlined below:

- **Ministry of Agriculture, Water & Forestry (MAWF).** The MAWF's Department of Water Affairs (DWA) and its related sub-departments are the primary organization responsible for managing the country's water sources. This department produces countrywide water resource management acts and works directly with NamWater to ensure the country has access to water. NamWater and the MAWF supply industries with a volume of bulk water per year as outlined in their operational permits. Industries must apply for increased water supply from the MAWF if they exceed their yearly supply.
- **Ministry of Environment and Tourism.** Within this ministry, the Department of Environmental Affairs (DEA) creates environmental regulations encompassing all natural resources (T. Nghitila, personal communication, March 26, 2015). The DEA is responsible for creating and enforcing regulations regarding pollution control and waste management as well as issuing industry clearance certificates [see *Table 4*].
- **Ministry of Trade & Industry.** This ministry, specifically the Industrial Development branch, is responsible for regulating the development of new industries in the country. This ministry develops policies regarding industrialization and promoting economic development.
- **City of Windhoek.** The DIWTS is responsible for enforcing city drainage regulations and monitoring water and effluents of industries within the city boundaries. The DIWTS visits industries of concern (regarding water and effluent) on a monthly basis. During these visits, they monitor water consumption and effluent quality. Following these visits, the DIWTS bills industries according to the effluent tariff charge in the Drainage Regulation Act (Kalimbo, S. and Lorraine !Gaoses, personal communication, March 23, 2015).

Interrelationships contribute to a complex regulatory system, especially when a new or existing industry seeks to obtain various operational permits. Complexities within this system originate from the overlapping responsibilities and insufficient communication between the necessary agencies. A breakdown of the model permitting process for new and established industries can be found in *Appendix F*. Highlighted throughout the process are a number of steps that are either skipped or performed inadequately. These deviations from the optimal processes contribute to ineffective industrial water and waste regulation. While *Appendix F* provides an in depth view of the role of these agencies in the process of permitting and certifying industries, *Table 4* highlights specific inefficiencies:

TABLE 4: INDUSTRIAL REGULATION INEFFCIENCIES

Permit/Process	Description	Responsible Agencies	Inefficiencies	Visual Representation
Fitness Certificate	Industry is suitable to establish and operate within respective facility	Issued by City of Windhoek Health Division & approved by DIWTS	Application is not sent to pertinent departments for approval.	Appendix F.b Appendix F.e
Discharge Permit	Industry is allowed to dispose of effluent under specified parameters	Issued by DIWTS within the city boundaries & DWA outside of the city boundaries	All industries that apply are granted a permit. There are no consequences for permits that are granted under conditions if conditions are not met.	Appendix F.c Appendix F.d
Clearance Certificate	Industry processes are deemed sustainable upon review of their Environmental Impact Assessment	Issued by the DEA & reviewed by DIWTS and DWA	Environmental Impact Assessment is not sent to pertinent agencies for approval.	Appendix F.g Appendix F.h
Permit to Operate	Industry is granted approval to operate	Issued by the Industrial Development Branch of the Ministry of Trade and Industry	Industries are approved to operate without an established property. These industries then establish in the city without notification of pertinent agencies.	N/A
Compliance Visits	Representatives visit industries to determine industrial compliance status with effluent regulations	Issued by the DIWTS & DWA	Both agencies are responsible for conducting visits but are enforcing different regulations. Neither agency monitors all industries consistently.	Appendix F.c Appendix F.d

In addition to flaws in the regulatory system, the content of the regulatory acts presents additional challenges in the enforcement process. The four regulatory organizations operate under the jurisdiction of the 1956 Water Act, the Drainage Regulations of 2010, and the 2013 Water Resource Management Act.

The 1956 Water Act. The 1956 Water Act exists, "to promote the maximum beneficial use of the country's water supplies and to safeguard water supplies from avoidable pollution". The two

sections regarding industrial discharge dictate that industries must meet requirements for wastewater treatment and disposal or can apply for exemption if they are unable to meet them (Ministry of Agriculture, Water & Forestry, 1956).

The Drainage Regulations of 2010. The Sewage and Drainage regulations are specific to the city of Windhoek and dictate that industries must have a permit for discharging effluent. Industries are charged for their effluent according to the tariff system. Effluent must be nonhazardous, treated to allowable concentrations, or disposed in a separate drainage system (Department of Infrastructure, Water & Technical Services, 2010).

The 2013 Water Resource Management Act. The 2013 Water Resource Management Act is in the process of being enacted by the national government to replace the 1956 Water Act. The 2013 Water Resource Management Act exists to, "provide for the management, development, protection, conservation, and use of water resources" (Office of the Prime Minister, 2004). This Act dictates that industries must have a permit to discharge effluent and construct effluent treatment facilities or disposal sites. Industries pay for this effluent according to the tariff system. The Act also outlines pollution contingency plans, exemplary water management practices and measures for protecting of the city's water resources (Office of the Prime Minister, 2004). The 2013 Water Resource Management Act is scheduled to be enacted August-September of 2015. Industries will have a grace period of one year to adapt processes to meet regulatory compliance.

EXPLANATION. Three obstacles to effective enforcement of regulations are:

- Distribution of Regulatory Responsibilities
- Communication
- Regulation Content

Distribution of Regulatory Responsibilities. The inefficiencies in the enforcement process are difficult to address due to the complexity of the system of stakeholders and the lack of communication between them. In 2009, Namibian government established a Water and Sanitation Forum (WSF) to centralize the departments and agencies involved in industrial regulation. The structure of the forum can be found in *Appendix Y*. The forum was also responsible for regulating the establishment of new industries in the country (Ministry of Agriculture, Water & Forestry, 2009). The forum was ineffective in improving industrial regulation in Windhoek for the following reasons (Hambabi, M. and Ivondia Karumendu, personal communication, March 24, 2015):

- **Inconsistency.** The WSF was inconsistent in their role of approving the establishment of new industries in the city. The WSF had their "hands full" with industries in the rest of the country among other duties, thus the WSF only evaluated a portion of new industries.
- **Inadequate Representation.** When the forum held meetings, some departments sent individuals who were not appropriate representatives for the forum.
- **Complexity.** As seen from the *Appendix Y*, the forum stakeholder web was as complex as the regulatory system it intended to simplify. Not all stakeholders were interested in the same issues or had the same goals for the forum.

The level of complexity in the distribution of regulatory responsibilities made it difficult to address the inefficiencies outlined in *Table 4*. In 2014, the governmental document that established the WSF expired, and no efforts have been made for its revival.

Communication. Poor communication between regulatory agencies exacerbates the effects of the system's complexity. According to two hydrologists at the DWA, because the responsibilities of regulatory departments are scattered, communication between them is "slow or nonexistent" (Hambabi, M. and Ivondia Karumendu, personal communication, March 24, 2015). Without effective communication, processes will not be followed as designed in *Appendix F* and inefficiencies will arise.

Regulation Content. The regulatory acts do not support the regulators in enforcement. The Water Act of 1956 contains the national regulatory standards for water use and effluent treatment. The content of the Act has become outdated and ineffective for the regulation of domestic and industrial processes. Regulatory policy does not specifically outline the consequences of failing to meet regulations. As a result, the city is restricted to enforcing regulations by means of an open dialogue. As a result, many industries continue to operate despite non-compliance. When enacted, the 2013 Water Resource Management Act will allow the court system to be involved in regulatory enforcement.

Inefficiencies within the regulatory system limit effective regulation of industrial water use and effluent treatment. The overlap in roles, the shifting of responsibilities between departments and the inconsequential regulations contribute to an ineffective regulatory environment.

Finding 2: As major providers of services or products in the Namibian economy, Windhoek's critical industries create complexities in enforcement of regulations.

SUMMARY OF EVIDENCE. Numerous industries in Windhoek provide critical services or products to the city's residents and are valuable to the country's economy. A single company produces 95% of beer sold in Namibia; another company is the sole large-scale dairy manufacturer in the country; the telecommunications sector is made up of two large companies; and only one large-scale meat manufacturing company that includes abattoir services exists in the country. Governmental influence within these essential industries emphasizes their vital role in the country. Examples of these governmental connections to these industries are described below:

- **Brewery.** In the 1990s, a South African brewery company attempted to buy the Namibian brewery company. The Namibian government supported the local brewery, rejecting the South African company's proposal to establish bottling plants in Namibia (Company website, n.d.).
- **Abattoir.** The national government is a stakeholder for the country's only abattoir. Two of the four abattoirs that this company operates are owned by the national government (Company website, 2015).
- **Telecommunications.** One of the main telecommunications companies is owned by the national government. This company's annual revenue is over N$1 billion.
- **Umbrella Company.** One company in Namibia owns over 15 entities and is one of the top employers in the country, employing over 5,000 Namibians. The company contributes to a large proportion of the country's GDP (Company website, 2015).

EXPLANATION. In the initial stages of establishment and growth of industry, natural monopolies are common in developing countries. This is true of Windhoek's critical industries. These industries are often the largest supplier of their specific good or service, have the largest influence on the price of production, and sway the establishment of competition. While monopolies are often perceived as a threat to free market, natural monopolies can be pragmatic for cost or virtually unavoidable in developing countries such as Namibia.

While these critical industries serve an imperative role in the supply of goods and the growth of the Namibian economy, their presence contributes to the intricacy of regulation. Regulations are enforced sporadically and by different means depending on the type of industry and their relationship with the government. One industrial manager described enforcement of effluent regulations as "selective" (Interviewee A, personal communication, March 31, 2015). Regardless of whether or not critical industries dedicate time and effort to adapting practices and improving infrastructure, the DWA representatives stated that some industries could never be shut down in Namibia regardless of their compliance status (Hambabi, M. and Ivondia Karumendu, personal communication, March 24, 2015). Legislation has a limited effect on the critical industries: fines are generally insignificant relative to the company's revenue and the risk for being shut down is not a plausible reality.

Finding 3: Unregulated industries within Windhoek's expanded boundaries, informal settlements, and growing industrial sector hinder consistent enforcement of regulations.

SUMMARY OF EVIDENCE. Unregulated industries contribute to the pollution of Windhoek's water sources, which is counterproductive of efforts made to monitor the regulated industries. Interviews with industrial managers and government representatives uncovered the lack of uniform enforcement of effluent regulations. The city does not regulate three categories of industries:

- Industries within Newly Established City Borders
- Businesses in Informal Settlements
- Growing Industries

Industries within Newly Established City Borders. The national government reviews and expands city boundaries every three years, causing industries that have previously been unregulated to fall under the jurisdiction of the DIWTS (Theron-Beukes, 2014). This poses a challenge for regulatory processes by the DIWTS. Monitoring processes and enforcing regulations on industries that have been encompassed by the city boundaries is reactive. This is because "the city doesn't have the resources to actually properly manage these expanding boundaries" (Trudy Theron-Beukes, personal communication, April 23, 2015). Unregulated waste disposal, inadequate effluent treatment, and deficient knowledge of regulatory processes plague the industries' ability to comply.

Businesses in Informal Settlements. Companies within informal settlements are small and not formally established. These companies tend to operate in ways that use water and produce effluents but do not have infrastructure to manage these processes. The DIWTS communicates to the informal industries regarding the measures they must take to comply with regulations. While

some informal industry owners are aware of how to meet these standards, effective regulation of these industries is limited by cost, location and mindset:

- **Cost:** The manager from Company Q needs technologies such as an oil trap, a spray booth and covered ground with a concrete roof to be in compliance with city facility regulations. Despite knowing these requirements, his company lacks the funds for these upgrades (Company Q, personal communication, April 13, 2015).
- **Location:** Many informal industries operate on the premises of their home or in zones that do not support implementation of effluent treatment infrastructure (Lorraine !Gaoses, personal communication, April 24, 2015). The city has attempted to assist informal industries in efficient operations by installing proper facilities in the informal settlements. Managers lack an incentive to move operations to these facilities and thus continue to operate in improper locations. (Lorraine !Gaoses, personal communication, April 24, 2015).
- **Mindset:** Kalimbo, the DIWTS pollution control inspector, stated that many owners of these companies view the city as the "enemy" (Kalimbo, S., personal communication, April 9, 2015), a mindset that prevents valuable communication and effective regulation.

Industries in informal settlements contribute to Windhoek's water pollution, but currently there is no way to properly regulate these companies.

Growing Industries. The DIWTS has a list of seventeen companies of concern that they monitor based on water consumption and effluent quality. These industries are of the largest in the city. As other industries establish and grow, they continue to be unregulated. Representatives from the DIWTS and DWA both expressed that when industries are small they are not taken into consideration by the city for regulation due to low water consumption and effluent concentration as well as minimal communication between owners and city officials before establishment (Kalimbo, S., personal communication, April 9, 2015).

EXPLANATION. Inconsistent enforcement of regulations of industries creates discontent from industries that are regulated. An industrial manager expressed that all companies should be treated equally and regulated by the same standards (Interviewee A, personal communication, March 31, 2015). As the DIWTS considers methods to regulate industries within the newly established city borders, informal settlements and the growing industrial sector, managers of these companies discussed the implications of new regulations on their operations. The manager at Company K stated, "I don't have any problem with regulations. The problem is, can I manage it [regulations]? Can it be costly to the company? Should I have closed my doors?" (Interviewee K, personal communication, April 16, 2015). Until the DIWTS can establish an effective way of monitoring every industry, industrial pollution will continue to threaten the city's water supply.

Finding 4: Rather than regulatory penalties, three motives—corporate responsibility, company values, and international image—drive industrial managers to improve waste and water management processes.

SUMMARY OF EVIDENCE. Industrial managers described several motives for implementing water saving and effluent treatment technologies. A breakdown of these motives can be found in *Figure 11*.

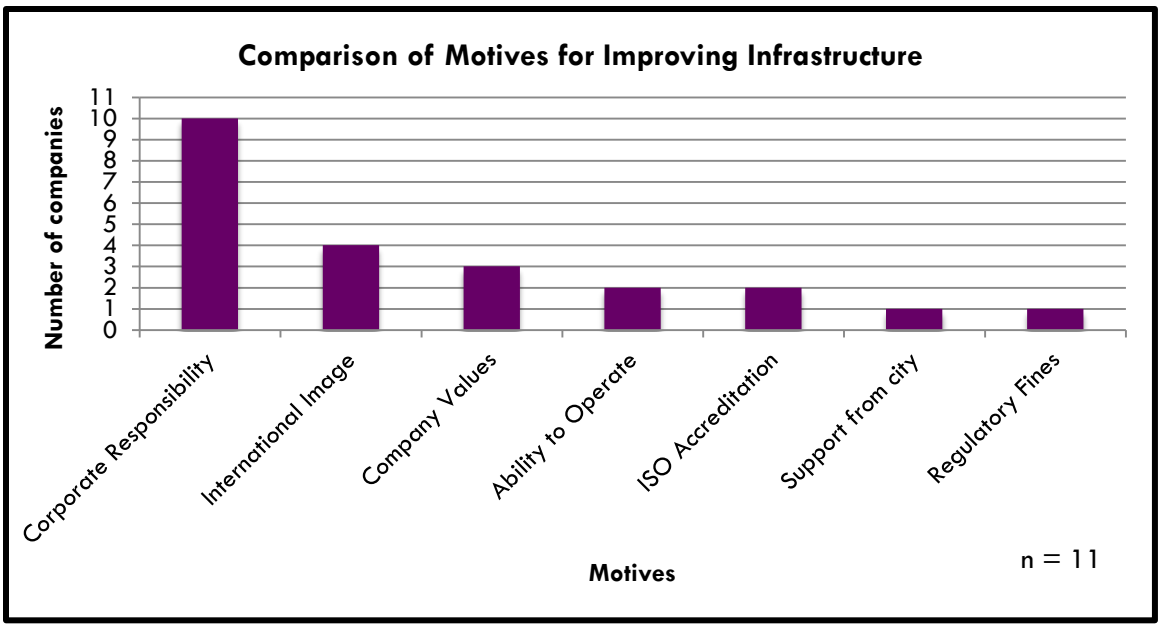

FIGURE 11: MOTIVES FOR INDUSTRIAL MANAGERS TO IMPROVE EFFLUENT AND WATER MANAGEMENT INFRASTRUCTURE

Industrial managers rarely discussed "regulatory fines" when considering their motives to implement improvements to their waste and water management systems. Companies are charged for their effluent based on four constituent concentrations and one volume flow parameter as part of a new tariff system implemented in 2013. Managers at companies such as Company F believe that there is merit in this new system; the city must change the system of billing to motivate non-compliant industries and to keep current industries in check. As one manager stated, "you're going to pay if you don't comply…when you touch a person's money, they pay attention" (Interviewee F, personal communication, April 9, 2015). Despite this viewpoint, only one of the eleven managers described the cost of effluent and water use as a motive to comply (Interviewee C, personal communication, April 2, 2015).

Rather than regulatory fines, the motives that were emphasized in our discussion with industrial managers included "corporate responsibility", "company values" and "international image". Below is a discussion of these three motives:

Corporate responsibility. According to ten of the eleven industrial managers, environmental responsibility is a reason for considering or implementing systems for efficient water use and effective wastewater treatment. Ten of the eleven industry managers spoke extensively about the severity of the drought in Windhoek, with one saying, "I'm going to be brutally honest. I think we are facing a *major* water crisis" (Interviewee D, personal communication, April 2, 2015). Company managers feel a strong sense of responsibility to alleviate the water situation in Windhoek, and their company is the main platform to act in this regard. When asked about why they feel a sense of responsibility, one manager spoke about the future of their company and Windhoek as a whole: "If we think of the future, we have to support these things [water saving measures]. If we think of ourselves now, it'd be different" (Interviewee H, personal communication, April 14, 2015). The state of water is extremely important to Namibians and to these operational managers who handle large water and effluent quantities on a regular basis. Because of this, the managers strive for their companies to operate in ways that cater to the environment and company success.

Company values. Industrial managers cited company values as a reason for efficient water use and effective wastewater treatment. All three of the managers who described company values as a motivation work for companies who fall under the same ownership. This umbrella company implemented a program in 2004, designed to instill company values among employees and restructure relationships in the company from rule-driven to value-driven (Company Website, 2015). The value that these industry managers referenced was "naturally today for tomorrow" and "doing the right things right" in the context of wastewater management and water consumption. Industrial managers referenced values from the program in relation to their motivation for implementing efficient water saving and effluent treatment infrastructure. This demonstrates the effectiveness of the values-based program.

International image. International image is a common motivation for industrial managers at the companies we visited, five of which export internationally. An operational manager at Company A discussed feeling a greater sense of responsibility to operate efficiently because of the large market for their product in both Namibia and South Africa (Interviewee A, personal communication, March 31, 2015). In the same respect, the operational manager Company C spoke about the importance of operating responsibly because it is attractive to customers in a global market (Interviewee C, personal communication, April 2, 2015). Companies who sell internationally tend to care more about their public image. As one industry manager put it, "there are more eyes on us" (Interviewee A, personal communication, March 31, 2015). Managers at international companies we visited had taken the most action to research and implement water saving and effluent treatment infrastructure.

EXPLANATION. Insufficient managerial understanding of the effluent billing system is likely a reason why companies are not motivated by regulatory fines to implement efficient technologies. Changes to the effluent billing system have increased awareness around effluent disposal, but awareness has not improved understanding of the penalties. Although industrial managers confirmed that the regulatory documents are accessible, seven of the eleven interviewees described an incomprehensive understanding of the regulations and how they are enforced. Contact between local regulatory authorities and industries is restricted to the mail. This is problematic because companies receive a bill stating the charges they have accrued, but do not fully comprehend what they are being charged for or how they can improve.

The city primarily enforces regulations through dialogue and charges for water use and effluent concentration. These methods of enforcement do not prompt concern for a status of non-compliance. Rather than motivating company efforts to improve processes, the new effluent billing system has discouraged progress. Company A pioneered many initiatives to lower their water consumption by introducing water saving technologies. Because of this, their effluent is more concentrated and the company is being charged more for effluent disposal while being charged less for water consumption. For companies much smaller than Company A, investing in technology that may not significantly reduce fines they receive deters them from considering other investment benefits. Ultimately, it costs less to pay for violations than it would to invest in alternative technology. In this sense, compliance penalties are merely a cost of doing business.

For company management that has dedicated time and effort to implement water saving and effluent treatment infrastructure, the motivation to do so is derived from personal or corporate values in conjunction with business sustainability. Corporate responsibility, company motto, and international image are all motivators that have two sides: personal and business. Both company

management and production employees are motivated to maintain personal income and employment while ensuring a secure water future. If there is no usable water the company cannot operate. Despite these motivations, there is a gap between motivation and effective action due to unpersuasive penalties.

Finding 5: Operational managers are aware of Windhoek's state of drought, but four factors hinder their efforts to adapt industrial practices to address the water crisis: monetary investment, time investment, company growth, and lack of knowledge of best practices.

SUMMARY OF EVIDENCE. In adapting business practices to address Windhoek's water crisis, companies face the following challenges:

Monetary Investment. The lack of financial flexibility restricts industries from adapting to drought conditions. Four representatives from industries indicated that the financial investment of implementing best practices is too large. The operational manager at Company A indicated that there is a lot of opportunity to save water, but the investment would not be worthwhile given the current price of water (Interviewee A, personal communication, March 31, 2015). Industrial managers do not wish to invest large sums of money to implement new technologies because the surcharges levied under current billing methods are cheaper.

Time Investment. Time constrains the implementation of water saving measures and effluent treatment technologies. Most industrial managers have multiple responsibilities such as quality control, operations management and engineering. Consequently, four of the eleven industrial managers discussed the concern of investing time into researching new technologies. Production time is the most important resource in a manufacturing company. One manager at Company F explained that the company was looking to implement new high-pressure washers into the current cleaning system. Implementing the devices would require the current cleaning system to shut down for the duration of implementation (Interviewee F, personal communication, April 9, 2015). As with Company F, many managers do not want to cut production time to implement new technologies.

Company Growth. Although growth of industries is important to the financial success of the region, it has presented challenges for companies to properly manage their waste and water. Four of the eleven industrial managers indicated company growth as a challenge. An industrial manager at Company B indicated that the company's operational plant was only designed for a certain volume of production (Interviewee B, personal communication, March 31, 2015). Due to company growth, the plant has exceeded that capacity. When demand for a company's product or service grows, the manufacturing process operates at a higher volume. The total quantity of waste produced and water used will increase, which inhibits effective management of waste and water.

Lack of Knowledge of Best Practices. A lack of knowledge of best practices prevents industries from implementing new technologies to treat effluent and save water. Due to limited feedback from the city, managers discussed that they are not able to identify where improvement is needed in their processes. Seven of the eleven industrial managers indicated that they are unaware of any best practices that could be implemented to treat wastewater or save water in the workplace. Managers from Company G and Company C acknowledged that practices exist elsewhere to

save water and treat effluent more effectively (Interviewee G, personal communication, April 9, 2015). Both of these managers indicated that they are unaware of what these practices are or how to learn about them. With limited knowledge and minimal feedback, industrial managers cannot take effective action to adapt their processes to address Windhoek's water crisis.

EXPLANATION. Monetary investment, time investment, company growth, and lack of knowledge of best practices are short-term limitations that inhibit long term sustainability and economic prosperity. As Windhoek's water situation continues to worsen, factors which limit adaptation of industrial practices will become exponentially more challenging to address. If companies do not adapt their business practices, they will eventually be unable to operate sustainably. When considering ways in which industries can be supported to adapt their water use and waste management practices, these four limitations should be prioritized.

Finding 6: While employees genuinely care about the city's water supply and economic success, their minimal knowledge levels and resistance to change workplace practices impede efforts for water conservation and effluent compliance.

SUMMARY OF EVIDENCE. For industries to implement new infrastructure, operators must be knowledgeable of the reason for the change and trained on the new processes. Industrial managers commented about challenges with employees when implementing new systems: minimal knowledge levels and resistance to change.

Minimal knowledge level. Employees with minimal knowledge about operational techniques regarding waste management and water conservation impede efforts for compliance with regulations. Two representatives from the DWA describe many challenges with managing wastewater that are connected to insufficiently skilled or knowledgeable industrial employees. The DWA often visits companies that have implemented treatment plant upgrades only to find that the person on site does not understand the system or the effects of the industry's waste due to lack of training (Hambabi, M. and Ivondia Karumendu, personal communication, March 24, 2015). Many industries are managing their own wastewater treatment plants which are often developed by South African companies. Proper operation of these treatment plants requires extensive training by manufacturing company personnel. Due to the low retention rate of plant operator positions, new operators are often not adequately trained to operate the treatment plant. This predicament has manifested itself at Company D. The maximum chemical oxygen demand allowed for effluent is 700 ppm, reaching levels as low as 200 ppm or as high as 1000 ppm depending on operator skill level (Interviewee D, personal communication, April 2, 2015). Additionally, spillage or overflow can also occur, "simply because the employee does not know how to operate the system" (Hambabi, M. and Ivondia Karumendu, personal communication, March 24, 2015).

Resistance to Change. Employee perceptions and attitudes towards procedural changes will dictate the effectiveness of implementing new technologies. Thus it is vital to ensure that employees receive proper explanation of the reason for certain effluent disposal and treatment methods. In the words of interviewee F, "If you don't really understand why you do what you have to do, you will one day decide not to follow that procedure" (personal communication, April 9, 2015). Company C cited this consideration in implementing one of their water saving techniques: squeegees. One year ago, Company C management provided the cleaning team with new

cleaning equipment including squeegees to reduce water use when removing solid particles (Interviewee C, personal communication, April 2, 2015). While the company provided training for the proper use of squeegees in daily work procedures, many employees are still using hoses to remove solid particles. The employees see the new equipment as simply something new they need to learn with little benefit to the efficiency of their tasks. Behavioral modification does not occur without a change in perception. *Figure 12* depicts the average degree of importance that industrial employees indicated when considering various water issues in Windhoek (blue). This is depicted alongside employee perceptions of importance of topics in their daily work life. Employees rated these topics on a scale from one to five, one being "not important" and five being "most important".

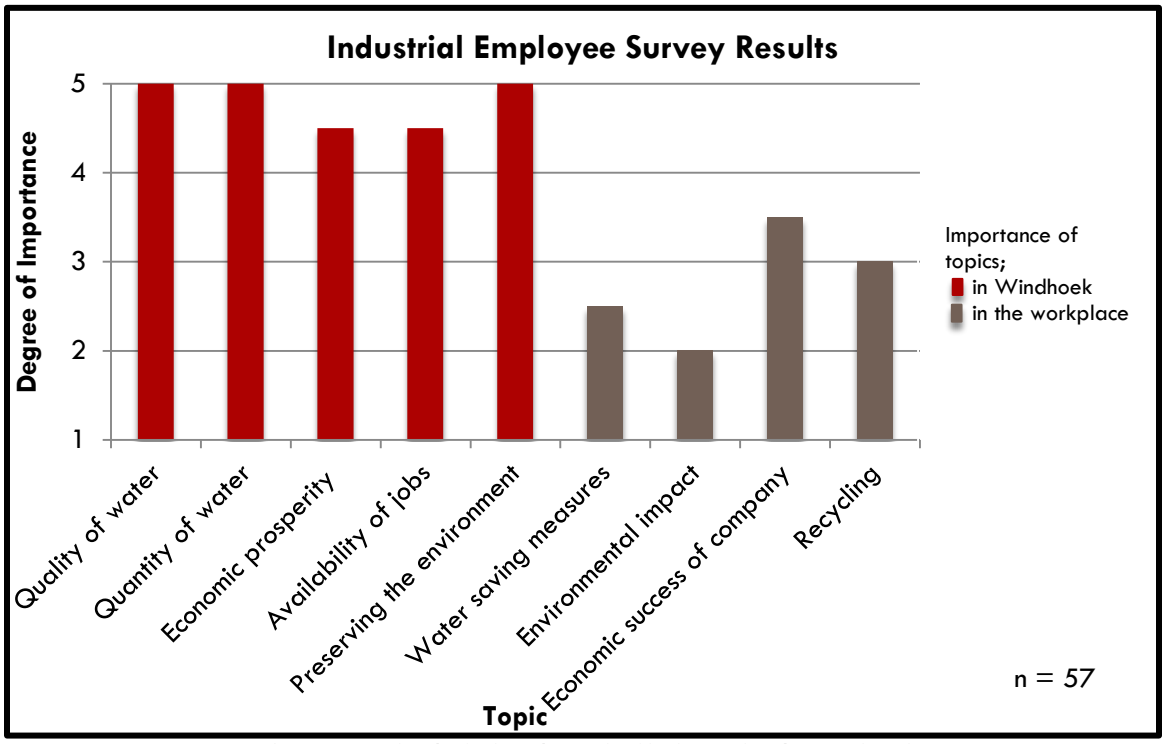

FIGURE 12: IMPORTANCE OF WATER TOPICS TO INDUSTRIAL EMPLOYEES

While employees genuinely care about the city's water, environment and economic success, these attitudes are not translated to the work place.

EXPLANATION. As company management continues to make strides to implement technology that would reuse water, reduce its usage, and treat the resultant effluent, employee work environments change. As a result, employees must learn how to adapt to changes. Without a logical progression of training, attitude shift, and behavioral modification, implementation of water treatment or water saving techniques lacks effectiveness for industries. While investing in training for industrial employees may be a fruitful initial step which industries can invest in, every operational manager described little to no training regarding these topics. Managers were all intrigued and somewhat enlightened by the idea of employee training but described the challenges that they see with implementation. Of these challenges, the most prevalent were time constraints and lack of knowledgeable staff members to train employees. While many managers spoke of time constraints on this topic, they all emphasized one major concern, summarized in the

statement by interviewee F who stated, “There is a serious issue with cutting time out in manufacturing” (personal communication, April 9, 2015). In considering implementing a training program for new employees about the initiatives regarding waste and waste management, operational managers also cite staffing as an inhibiting factor. Many of the personnel we spoke with are the most knowledgeable about water and waste management procedures within their company. Though they would be the optimal person to perform this training, they hold many responsibilities that monopolize their time.

5. CONCLUSIONS & RECOMMENDATIONS

Our interactions with representatives from the DIWTS, DEA, and DWA helped us understand the current regulatory process. The current process of regulating industrial waste and water management scatters responsibilities across various governing organizations. Communication between pertinent governing organizations is lacking, which adds to the ineffectiveness of the regulatory process. Our interactions with industrial managers allowed us to gain insight on challenges they face with meeting regulations. Industrial managers provided us with their motives for attempting to comply with regulations and suggestions on how they could be supported to meet regulations. The surveys that we distributed to the employees at the industries we visited helped us understand their perceptions on the drought, water reclamation, as well as water and economic topics within their industry and the city. The surveys also helped us understand what water saving measures the employees perform in their daily lives.

Through these methods, we identified six findings as outlined below:

1. The complexity of regulatory agency responsibilities and the inconsequential nature of the legislation they enforce contribute to ineffective enforcement of industrial regulations.
2. As major providers of services or products in the Namibian economy, Windhoek's critical industries create complexities in enforcement of regulations.
3. Unregulated industries within Windhoek's expanded boundaries, informal settlements, and growing industrial sector hinder consistent enforcement of regulations.
4. Rather than regulatory penalties, three motives—corporate responsibility, company values, and international image—drive industrial managers to improve waste and water management processes.
5. Operational managers are aware of Windhoek's state of drought, but four factors hinder their efforts to adapt industrial practices and address the water crisis: monetary investment, time investment, company growth, and lack of knowledge of best practices.
6. While employees genuinely care about the city's water supply and economic success, their minimal knowledge levels and resistance to change workplace practices impede efforts for water conservation and effluent compliance.

5.1 Recommendations

From these findings, we have identified seven recommendations, classified into the following four groups:

- Recommendations for Improved Enforcement of Regulations
    1. Establish a water forum involving representatives from regulatory agencies to address communication flaws and develop a consistent system of industrial regulation.
- Recommendations for Improved Compliance to Regulations
    2. Provide recognition and a monetary incentive for industries to comply with regulations by reducing water usage and improving effluent treatment.
    3. Develop a program to meet regularly with industrial managers to improve transparency of regulations, build personal relationships, increase cooperation between the city and managers, and improve regulatory compliance.
    4. Require that industrial management develop a water-conservation training program for employees to address the effects of two factors—minimal knowledge of water processes and resistance to change practices—on regulatory compliance efforts.
- Recommendations for Increased Community Involvement

5. Create a committee to develop and maintain a new awareness campaign to educate the general population on water saving practices.

- Recommendations for Future Research
  6. Conduct a study on unregulated industries, which are polluting water resources in Windhoek, to understand their current waste disposal practices and water usage.
  7. Conduct a study on the effectiveness of the newly implemented public awareness committee to determine the success of outreach strategies in decreasing the city's water use and educating citizens on the current water situation.

Our findings demonstrated the complexity of water provision and waste regulation in the city. Providing the DIWTS with recommendations will assist them in evaluating their current methods and developing further improvements in conjunction with other regulatory organizations.

Recommendations for Improved Enforcement of Regulations

RECOMMENDATION 1: Establish a water forum involving representatives from regulatory agencies to address communication flaws and develop a consistent system of industrial regulation.

The lack of effective enforcement of regulations in Windhoek contributes to an atmosphere with lax industrial practices and excessive pollution of water resources. We recommend that, in conjunction with the Department of Water Affairs (DWA), the DIWTS develop a water forum specific to Windhoek's water and industrialization. Using Namibia's previous model, the Water and Sanitation Forum (WSF), this new forum could serve a similar purpose, but address some of the problems that the WSF faced. **When establishing the new water forum, we suggest the following solutions to address the failures of the WSF:**

- Focus on specific topics of industrialization and industrial waste and water management to keep the forum's goals clear.
- Appoint individuals to the forum who hold relevant positions within the organizations involved, ensuring consistent and stable operations.

Figure 13 depicts the recommended organizations for the new forum and its basic goals:

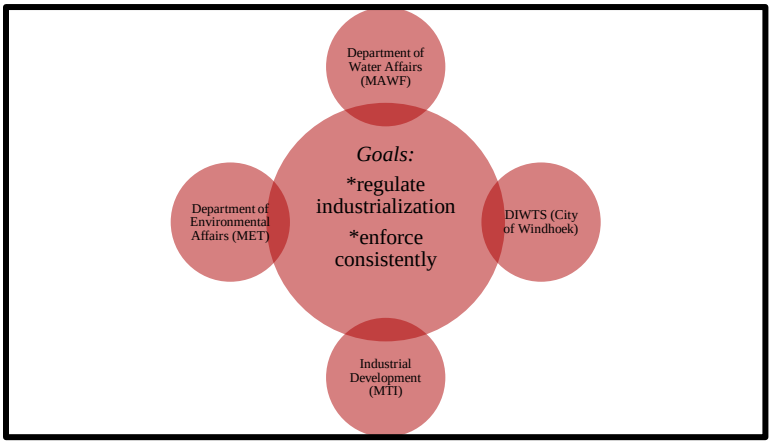

FIGURE 13: NEW MODEL FOR WINDHOEK WATER FORUM

The purpose of the forum is twofold:

1. Serve as the primary source of approval for new industries. This would include industries in the city of Windhoek, informal settlements, and those newly encompassed within the city boundaries.
2. Establish consistent methods for enforcement of regulations. The individuals from each department will review current enforcement processes and identify strategies for improvement. Most importantly, the forum will develop one consistent form of enforcement of regulations.

To effectively achieve these goals, **we recommend that the forum meet on a monthly basis.** This time frame will optimize the existing enforcement practices since industrial compliance visits are performed monthly. Additionally, **we recommend that the forum uses best practices outlined in the "Punishment Paired with Cooperation" regulatory approach** (Shapiro & Rabinowitz, 1997). This approach emphasizes cooperation and communication with techniques such as strategic regulator roles and violations.

The establishment of the new forum would not come without limitations. The department managers must support the idea of the forum, and allow representatives from their organizations to serve and dedicate time to completing its goals. Additionally, each person is a representative of a larger regulatory body, and the messages and actions of the forum need to be relayed to the regulators as well.

Recommendations for Improved Compliance to Regulations

RECOMMENDATION 2: Provide recognition and a monetary incentive for industries to comply with regulations by reducing water usage and improving effluent treatment.

Companies lack incentives to comply with regulations. Fines and violations are viewed as the cost of doing business, and the implementation of new technologies to treat effluents will cost more than the monthly regulatory fines imposed by the city of Windhoek. As interviewee K stated, "in Italy and China, the government gives the companies incentives…in Namibia, you're your own incentive" (Interviewee K, personal communication, April 16, 2015). The implementation of an incentive-based program would be beneficial, as it would promote environmental sustainability and regulatory compliance. Incentive-based programs can be implemented by the DIWTS via two methods.

First, we suggest that the water forum provide one yearly subsidy to a single company that has shown the most improvement in their effluent results and water efficiency. In addition to the subsidy, we recommend that certificates for environmental sustainability be given to the top three improved industries. Optimally, the involved organizations of the water forum would implement a marketing campaign directed toward local industries that consume large amounts of water or dispose of highly concentrated effluent. Although the marketing would focus efforts towards these industries, the application for the certificates and subsidy would be voluntary. Any industry in Windhoek that has made improvements in water efficiency and effluent disposal results is eligible to apply. To market this idea, we recommend the forum conduct outreach though

newspapers, emails, letters, telephone calls, and site visits. At the end of each year, the forum should evaluate the progress of each company's proposal based on improvements in water consumption and effluent concentration. The water forum would determine the recipient of the subsidy and the certificate from these results. Certificates will be given to the top three companies (gold, silver, and bronze) with a subsidy provided to the top industry. Certificates displaying a company's environmental efforts have proven to be a successful incentive in Mexico's "Clean Industry Program", as discussed in section 2.4. Result of this program could be posted in the newspaper to give public recognition to the winning companies and the technologies implemented.

This strategy has been successful in motivating industries to strive for improvement. For example, in Singapore, a water conservation organization provides certificates of recognition to industries each year that have improved water efficiency and minimized usage (PUB, 2015). To take this step further, the Welsh government provides platinum, gold, silver, and bronze awards to industries that have demonstrated improvement health standards for their employees ("The Corporate Health Standard", 2014). Lastly, an international economic consulting firm, Universal Access and Service (UAS) describes the benefits of implementing a program where industries compete for subsidies. "Smart subsidy has emerged as a best practice approach," following specific guidelines: operating with transparent and pre-established rules, linking subsidies to optimal results, supporting cost minimizing incentives, and facilitating good governance ("Competing for UAS Subsidies", 2015). A combination of these best practices can provide a strong incentive for industries to manage water and effluent more effectively.

For the implementation of the subsidy strategy, potential risks have been outlined that should be avoided, including: distorting the market, creating dependency on funding, abuse of funds, favoritism, and project failures that waste resources ("Competing for UAS Subsidies", 2015). The future goals of this strategy would be to provide smaller subsidies for the industries receiving the silver and bronze awards. Another potential limitation to the incentive program is voluntary participation. Voluntary participation may only attract certain types of industries. Industries that work internationally may be more attracted than other companies to use the recognition as a marketing tool. Other industries that work with the government may be more interested in this program than private industries. This strategy would need to emphasize that all companies have equal opportunity to receive the subsidy and awards.

Second, we suggest that the DIWTS provide companies with effluent cost reduction incentives for the implementation of effluent treatment systems. When companies are not complying with effluent regulations, we recommend that the DIWTS:

- Conduct an inspection of the company's existing effluent treatment system
- Provide recommendations for specific treatment system upgrades to improve effluent quality
- Negotiate a percentile cost reduction in effluent charges over a predetermined time frame

This process will help companies finance the implementation of upgrades after the industry has developed an action plan and schedule for construction. Companies who are complying with regulations but need financial assistance in implementing new technologies to improve their effluent quality are also eligible.

The United States implemented a similar strategy entitled Supplemental Environmental Projects (SEPs). Industries negotiate a decrease in their environmental violation penalties with an agreement to implement an alternative environmental project. The program was effective because

of the potential advantages of improved environmental performance including: positive publicity, reduction in waste management costs, and early preparation for future regulations ("The United States Experience with Economic Incentives for Protecting the Environment", 2001).

To effectively implement both of these programs, the forum must determine the value of the subsidies and cost reductions as well as their sources. As monetary investment from the forum may not be a possibility, implementing these programs may require seeking external investors. Both the regulatory authorities and industries will need to invest in these methods for optimal results. Their joined investment will help maintain an acceptable quality of effluent entering the water reclamation plants, thus reducing the price for maintenance and increasing its operational lifespan.

RECOMMENDATION 3: Develop a program to meet regularly with industrial managers to improve transparency of regulations, build personal relationships, increase cooperation between the city and managers, and improve regulatory compliance.

By interviewing industrial managers and government representatives, we found that these two groups communicate poorly with one another. Company managers acknowledged that effluent regulations are available to them, but they feel the charges are often unfair or confusing. The only information provided by the city to companies about water use and effluent disposal is through billing. The content of the bills is often unclear, which can create frustration. **Therefore, we recommend that the DIWTS implement a program for meeting with industrial managers to explain the effluent and water consumption readings they compiled for each industry.** The meetings should occur individually with managers of each industry currently being regulated. Meetings should occur on a quarterly basis in the initial year of this new program. Providing transparency to the industrial managers regarding regulations, effluent and water consumption readings, and charges will help industries understand how they can improve and alleviate any confusion of regulatory bills. After the initial year, meetings should occur twice per year. This will still allocate time for communication between managers and DIWTS representatives about billing and suggestions for improving current practices. Meeting twice a year will reduce the demand on both the managers and DIWTS representatives while still providing opportunities for discussion.

We recommend that the DIWTS implement meetings in conjunction with the enactment of the 2013 Water Resource Management Act. Upon enactment, the new regulations should be discussed with industrial managers to provide clarity and alleviate any confusion that may exist. The discussion of new regulations should be the initial meeting of the new program. Communicating the goals of this program to industrial managers can be accomplished in various ways. The first would be to enclose information about these meetings with each monthly bill stating the date of implementation and goals for the new initiative. The second would be to email and phone each industrial manager. The third would be to hand deliver information regarding new initiative when samples are taken at each company. The first of these meetings would introduce the purpose for and the goals of the new initiative to relevant industrial personnel.

The structure for the quarterly meetings should be an open conversation between both parties. **We consider the following topics to be valuable for conversation and recommend that they are discussed each meeting:**

- Effluent disposal and water consumption readings
- Calculation of charges by the effluent formula
- Suggestions for feasible water and waste management techniques
- Suggestions for and evaluation of employee training & awareness
- Current Windhoek water situation
- New industry incentive program

To foster constructive communication between the city and industrial managers, **we recommend that the city make efforts to develop relationships with industrial managers to alleviate any existing frustrations.** Both the industrial managers and city representatives must be aware of the essential nature of working together to address the major issues that the city faces.

We have identified two potential limitations to this recommendation, the first being the availability of DIWTS personnel. Staff members must be available to fulfill the duties required for these meetings. With the city representatives already managing many responsibilities, it may be difficult for the staff members to take on additional obligations. The second limitation is organization of meetings. This is important because scheduling must be optimal for the DIWTS representatives and each manager in Windhoek. To combat this issue, the DIWTS could schedule meetings well in advance. This would help industrial managers commit to these meetings and plan their operations around them.

RECOMMENDATION 4: Require that industrial management develop a water-conservation training program for employees to address the effects of two factors—minimal knowledge of water processes and resistance to change practices—on regulatory compliance efforts.

We recommend that the DIWTS require industry management to develop and implement training programs for employees regarding proper water use. These training programs will benefit both the companies and the city of Windhoek.

This requirement would fit well into establishing industries. Any company that desires to establish operations in the city must submit an application to the DIWTS to receive their permit to operate. We recommend that the DIWTS include a requirement for employee water conservation training in the permit application. We also suggest that the DIWTS impose this requirement on existing industries, giving them a period of one year to develop and implement the program. This could be considered for incorporation in the one-year grace period industries are given after the 2013 Water Resource Management Act is enacted. If an industry does not develop an employee-training program within the year period, the punishment should be enforced in conjunction with the penalties outlined in the 2013 Water Resource Management Act. The 2013 Water Resource Management Act does not state consequences for the lack of employee training programs. Therefore, we suggest that penalty amendments to this Act be discussed in the water forum.

Because industries use water in different ways, each company's management would develop their own program. To help these industries develop training programs, the DIWTS should design a general template. The industrial managers can use this template to create a program specific to their industry. This would allow companies to customize their training program in a way that fits their operations. Once the company develops the program, the DIWTS must approve it to ensure

that it is sufficient. We recommend that the DIWTS require the program to include the following elements:

- Information on effluent production through company's operations
- Information on how water is used in the company's operations
- Information on Windhoek's water sensitivity and the importance of saving water
- Specific water saving measures that employees should use in their job duties
- Consequences for employees who consistently fail to follow the appropriate water saving measures

Company management must think critically about their own water use when developing the program. Thus, the effect of the program is twofold, contributing to the water saving mindset amongst industry managers and providing training to employees.

We acknowledge that requiring this training program comes with limitations. The first limitation is that it is easier to implement this requirement on new industries developing in the city rather than existing industries. This presents a problem because the city is approaching its limits of industrialization while existing industries struggle to minimize water consumption. The second limitation to the program is that it would not apply to industries on the outskirts of the city, which would present problems with implementing the program within existing industries if the city boundaries continue to expand.

Recommendations for Improved Community Involvement

RECOMMENDATION 5: Create a committee to develop and maintain a new awareness campaign to educate the general population on water saving practices.

To improve public awareness about the water challenges in Windhoek, we recommend that the City of Windhoek Branch of Water Demand Management and the DIWTS spearhead the development a public awareness committee headed by government representatives and community members. The purpose of this committee would be to educate city residents on topics such as the country's water resources, Windhoek's water reclamation and current water crisis, and water saving techniques. After the establishment of the general awareness campaign, the committee could develop campaigns targeting specific populations to enhance the program's effectiveness. These populations could include students, industrial employees, and residents of the informal settlements. **We recommend this committee conduct outreach to assemble volunteer groups.** These volunteer groups would be a key part of community based outreach. Community members are the best sources for identifying strategies to engage the population. We also suggest the conducts outreach via radio, newspaper, and newsletter marketing. As a result, city residents will gain a better understanding of the current state of the water supply, how it has improved or worsened over time, and the measures they can take to maintain a sustainable water supply for the city.

To improve general population awareness the city could implement two initiatives: enact an educational curriculum and establish a mascot and slogan for water awareness. An educational curriculum for students of all ages would help educate the city's youth on the importance of the water issues Windhoek faces. The use of a mascot and slogan for water

awareness has proved to be a successful method in Singapore, where their governmental organization implemented a mascot named "Water Wally". The same governmental organization developed a school outreach program that integrated water conservation in the curriculum. "Water Wally" is the face of all strategies they implement, which has helped them successfully save water in many ways. For example, as of 2013, the schools with the curriculum led by "Water Wally" save over 88,000 liters of water per week (PUB, 2015). Implementing an educational program into Windhoek schools would allow for outreach to a large population. If the DIWTS develops a mascot and slogan, citizens will associate the idea of the mascot with important topics concerning water in the region. We recommend that the city use these strategies to educate the public about their water and the issues the city faces.

A limitation to this recommendation would be the interest and cooperation of the community. For awareness campaigns to be successful, the target population must be willing to cooperate and have an interest in the subject matter. The city can use the strategies outlined in this recommendation to deliver information in a way that will stimulate the population's interest. Another limitation is the designation of individuals responsible for committee projects. People must be willing to dedicate time towards this committee and its maintenance. The operations of the committee would need proper funding to be effective.

Recommendations for Future Research

RECOMMENDATION 6: Conduct a study on unregulated industries, which are polluting water resources in Windhoek, to understand their current waste disposal practices and water usage.

Through our interviews with industrial managers, we found that the enforcement of regulations was inconsistent among all industries. Certain industries are not regulated by the city. These industries include formally established industries within the industrial sector of the city, industries within the informal settlements, and industries on the outskirts of Windhoek city boundaries. **Therefore, we recommend that the DIWTS or other research partners conduct a representative study on industries that are not currently regulated for effluent disposal.** This study would consist of different topics concerning unregulated industries with an end goal of implementing and enforcing consistent regulations to all industries in Windhoek.

For unregulated industries in the industrial sector, on the outskirts of the city, or the in the informal settlements, the effluent management is non-existent. **We recommend that the study conducted on these industries include an understanding of how these industries contribute to the pollution of Windhoek's water resources.** While the DIWTS understands how regulated industries affect the city's water sources, more must be done to understand how non-regulated industries are affecting the city's water quality**. In connection to this, we recommend that this study determine a way to implement consistent regulations to all industries and understand the implications of implementing regulations within the currently unregulated industries.** It is important to devise a way to integrate the effluent regulations within unregulated industries and to acknowledge the challenges and implications of enforcing them. The unregulated industries will not be able to comprehend and abide by the effluent regulations immediately. Industries may face challenges due to the lack of equipment, proper facilities, or financial resources. Therefore,

the implications of implementing these regulations within all industries must be assessed before action can be taken.
Other considerations for topics within this study would be to:

- Understand the level of knowledge company managers and employees have on the city's water situation.
- Learn the water use and effluent management practices within these industries.
- Understand industrial manager knowledge on how their company's effluents and water consumption impacts Windhoek's water supply.

Identifying ways in which the city can foster relationships with these industries can help industries become acclimated to the regulations.

A limitation to conducting this study is that it necessitates additional responsibilities of the staff at the DIWTS. Alternatively, the DIWTS could hire an external organization to complete the research that would require additional funding. **Therefore, we recommend that a research partner such as future WPI students conduct this study to aid the city.** As with our study on regulated industries, this research would be limited by industry sample size. Future researchers should take careful consideration in selecting a representative sample of the unregulated industries.

RECOMMENDATION 7: Conduct a study on the effectiveness of the newly implemented public awareness committee to determine the success of outreach strategies in decreasing the city's water use and educating citizens on the current water situation.

The DIWTS previously used an awareness campaign targeted toward the general population. The city did not evaluate the effectiveness of this awareness campaign and since have discontinued these efforts. In correlation with our recommendation to create a public awareness committee, the awareness campaign strategies this committee develops should be evaluated to determine their effectiveness. **This research would benefit the development of future campaign strategies by determining how effectively the campaign educated the Windhoek citizens on the following topics**:

- Water scarcity & drought conditions
- Water reclamation
- Water saving measures

Additionally, **this research would determine the effectiveness of various outreach methods to the city's residents.** The specific strategies that should be analyzed are as follows:

- Newspaper
- Radio
- Newsletter Marketing
- Volunteer Groups
- Water Curriculum in Schools

- Mascot/Slogan

With the information gathered in this research, the public awareness committee can decide to continue certain campaign strategies or to implement new public outreach methods. Understanding the effectiveness of the campaign strategies enables the city to make improvements for the next campaign.

One consideration which must be addressed when conducting this study is the method by which data is collected. While surveying the public is the most feasible method, our experience taught us that it can be very difficult to obtain a representative sample. Thus it may be beneficial to explore alternative options for conducting this research.

5.2 Considerations for Future Researchers: Connecting Society & Technology

Through the course of our research in Windhoek, we determined components of our experiences that helped us understand the broader context of our project.

1. The purpose of completing a project is not simply to benefit a single organization but to consider how the project can create change to a region as a whole.

In a different country, it can be easy to fall into the trap of seeing a problem from the perspective of one source. Our conversations with representatives from the DIWTS, the DWA, and DEA exposed us to one side of the problem: that industrial non-compliance is the primary challenge for their departments. Thus, in describing the problem and its implications for the residents of Windhoek, it was easy to discuss the negative role of industries in the growing water crisis. To understand what limits industries and how to invoke change, we needed to conduct most of our research with personnel from these industries. We wanted to understand factors for non-compliance and what prevents them from changing.

Introducing our project to industrial managers with those goals sometimes created apprehension. Thus, we began to consider the implications of our project not only for our sponsoring organization, but also for the people sitting across from us in interviews. No problem has one side, and every stakeholder has a different perspective. If we consider that each stakeholder must work together for the success of our recommendations, then we must foster this collaboration with every interaction. Indeed, we attempted to determine the limitations to industrial compliance, but we also tried to understand how the city can better support industries in compliance efforts. Every stakeholder is a moving part of a whole entity that would be affected by our project. Thus, the project became more significant for us as we considered the implications for each stakeholder.

2. Using a well-known and experienced liaison is important for facilitating interactions and increasing credibility.

Our liaison was Salatiel Kalimbo, the Pollution Control Inspector for the City of Windhoek. Working for many years at the Gammam's Water Reclamation Plant Laboratory before coming to work for the city, his association with many people in the field of water and waste management conferred credibility upon us. Within the DIWTS, Kalimbo is the primary person who consistently visits industries within the city to sample their effluent. Thus, we greatly valued our relationship with Kalimbo as we visited reclamation plants, interviewed industrial managers, and discussed the current water situation in Windhoek.

Kalimbo's connections expedited the process of contacting relevant personnel and travelling to the locations. As a respected employee of the city, he provided us with opportunities to interact with personnel whom we may have had a difficult time scheduling interviews ourselves. Being knowledgeable of the effluent treatment technology in Windhoek industries, he provided us with valuable background of the industries that we visited. He provided insight on the infrastructure of companies and how this compared to that of similar companies. Lastly and perhaps most importantly, he has knowledge of the tensions and history between Windhoek industries and the government as well as races and culture. His presence was essential when we visited and discussed with industrial managers.

3. The effectiveness of a research project relies on the ability to interact with people who have stake in proposed solutions.

Before coming to Namibia, our group's foundation was solely based on research of Namibia as a country and the factors affecting water supply and pollution. This provides a good understanding on the general problem, but does not allow for consideration of individual stakeholder perspectives. Within and outside of the work setting, direct exposure to the problem and the people who are connected to it resulted in a refined perspective of the problem and who it affects. Our viewpoint expanded to encompass the project's implications for the DIWTS, industries, and Namibian society, which ignited our passion for the project. We found ourselves with an influx of ideas to aid in addressing the core problem. With this, we needed to strategically approach the problem in a way that would produce pertinent solutions for the DIWTS and the people of Windhoek. While we gained useful data for our project from managers, employees, and citizens, the questions about their opinions and lives in relation to this problem gave us the most valuable insight as to how to best tailor our recommendations. Within one year, the livelihood of every individual we spoke with will be unsustainable if nothing changes. Thus, we must ignite change in the same way it ignited in us.

5.3 Project Conclusion

The goal of this project was to reduce pollution of Windhoek's water sources by identifying limitations that industries face when attempting to meet effluent regulations and manage water consumption and to develop strategies for improved industrial compliance. We found that the local and national government both have a role in the regulatory process but often do not communicate effectively. Ineffective communication often leads to growth of the industrial sector in Windhoek without water resources to support this growth. Additionally, ineffective communication leads to industrial development in locations detrimental to Windhoek's water sources. As a result, new industries are not informed of the proper infrastructure for managing their effluent. Combined with the lack of an effective regulatory environment, many industrial managers identified concern for the water crisis in Windhoek but struggle to adapt business practices to accommodate the situation. The lack of communication and cooperation between industries and the city has been a major cause for the pollution of Windhoek's water resources. By following the recommendations in this report and continuing to develop research on related topics, the DIWTS can support industries in achieving regulatory compliance, ultimately improving the quality of water in Windhoek.

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Appendix A: Oral Interview Question Outline for Experts

Introduction script: To open, we just want to tell you a little about us and what our goals are for this interview. We're working with the Department of Infrastructure, Water & Technical Services as part of a four month long project in conjunction with our university in the United States. Our project goal is to assist the efforts of the DIWTS regarding the pollution of sanitary water sources in Windhoek. To do this, we will be investigating industrial waste and water management practices and comparing them to city regulations and best practices to eventually determine the limitations which inhibit industrial compliance. In order to complete this process, we wish to interview experts in the fields of waste and water management within the city to gain further insight into the current systems that exist and how they function in terms of water provision and waste management. Any information you are willing to provide today will allow us to accomplish this goal and will be used for the sole purpose of informing our further research.

Expert Interview Questions—Department of Infrastructure, Water & Technical Services

- What do you currently do for the DIWTS? What have you done prior to this job? What attracted you to this job and this profession?
- Can you tell us more about your awareness campaign and water saving campaign? What do these entail and how effective have they been?
- We have learned that there are many organizations involved in water provision, management, treatment, and infrastructure (DIWTS, NamWater, Department of Agriculture, Water, and Forestry, city government and other related organizations). Who is responsible for what and how do you work together?
- How should we go about determining the specific individuals to talk with when consulting with industries, city government, and the DEA?
- When visiting industries what indicates a strong effluent treatment infrastructure? What information is provided to the industry about pollution control and water treatment when constructing their business?
- When industries do not meet regulation for effluent treatment, what is the action that you take and the city takes? What are the general reactions from these industries? How effective is this action in causing an industry to comply better?
- How are regulations communicated to industries and are there any inefficiencies to communicating these regulations to industries?
- We have researched the pollutants that you have provided to us and their effects on drinking water quality as well as water treatment processes. Are there any of these that are of greater concern than others?
- Do you ever have complications with solid waste from industries that is harmful to water sources?
- Are there any other factors such as pipeline bursts or infrastructure failures that result in pollution of water sources?

Expert Interview Questions—Water Affairs

- Can you describe what your organization does? What do you do for this organization?
- What is your responsibility within the regulatory process of industrial water and waste management?
    - How are your regulations communicated to industries?

- How does the city project estimates for the yearly water consumption, both industrial and municipal?
    - Has this yearly consumption ever been exceeded? What occurs when this happens?
- What do you do to monitor and control the water consumption of industries? Are industries generally consuming acceptable amounts of water?
- What are the major challenges that you see with industrialization for water sources?
- What is the biggest challenge for your department in terms of the current water challenges in Windhoek?
    - In terms of the current water supply, what actions do you feel need to happen in the foreseeable future in order to ensure that Windhoek residents and/or industries are consuming sustainable amounts of water? (for example, water rationing, dry industries, etc.)
    - We have studied some of the proposed options for expansion of Windhoek's water sources. Are there any viable options for expansion of Windhoek's water supply?

Expert Interview Questions—DEA: Environmental Ministry

- Can you describe what your organization does? What do you do for this organization?
- What is your responsibility within the regulatory process of industrial water and waste management?
    - How are your regulations communicated to industries?
    - Are there any efforts being made to assess any illegal discharge of industries?
- What are some of the major sources of pollution in Windhoek and what are the major effects of the pollution? What effects do the industrial pollutants have on the environment?
- What have been the major environmental impacts of industrialization?
- What have been the major environmental impacts of urbanization?
- Is there evidence that these phenomena have impacted the water supply in Windhoek?
- What is the biggest challenge for your department in terms of the current water challenges in Windhoek?
    - We have studied some of the proposed options for expansion of Windhoek's water sources. Are there any viable options for expansion of Windhoek's water supply?

Appendix B: Expert Interview Summary—DIWTS

What do you currently do for the DIWTS? What have you done prior to this job? What attracted you to this job and this profession?

- *Kalimbo:* When the city realized that there's a need to monitor and control industrial effluents, I was appointed as a pollution inspector to maintain the industrial waste, take samples, do inspections for new industries before they begin operation to ensure they will meet all requirements, his position has increased to include public compliance and storm water channel, advise communities what to do, manages any incident around the city that involves chemical spills, effluents, anything dangerous to environment, also involved in educational campaign for industries and best practices within industries
    - The requirements for the position for mathematics and physical science, and that's how I got involved in the position.
- *Lorainne:* Water is recycled. At one point city was not sure as to what was going into the city, initially industries were not allowed in the south of the city. My position is to be sure of what goes into the position and responsible for charging for discharges
    - I got into position because I studied chemistry. Within the city the only other place I would work would be in a lab, but Namibia does not have many labs. I used to tutor at UNAM when I finished university there. The position was originally based on point source, but as we went on, the DIWTS realized it's not only the industries, but illegal activity with no regulations and storm water problems. Because of this, the DIWTS had to jump in and start to monitor that. Old drainage regulations did not control nonpoint source, and in 2010, they added nonpoint source requirements

Can you tell us more about your awareness campaign and water saving campaign? What do these entail and how effective have they been?

- Most of the awareness campaigns are directly with industries where we had meetings with them. In most industries, managers are in profit and running the company. They tend to neglect water and waste. Campaigns have been directly with operation managers and CEOs, we invite them to a dinner and have presenters on topics of industrial waste and education. It's important to make sure industries don't think we are penalizing them.
- Other campaign was on environmental management when another person came in to talk. This campaign was less formal.
- Kalimbo and Lorraine used to go out to visit the industries as well to give them basic information on products they use. They focused on if they know that if they discharge things that it will affect the environment. They found that generally, on a day-to-day basis, they just think about production. The department gives them basic information on housekeeping for good practices.
- *Kalimbo added:* The reason why it was necessary to have someone inspecting them on an early basis is because sometimes the industries apply for business certificates and they follow correct procedures to get the certificate, but after the get it, their facilities are not in proper condition. We also realize with that, most of them are not aware of the purpose of the treatment they have put in place (fat traps & oil traps) so we did one campaign on that with pamphlets that explained the reason for them and everything.
- Engine oil industries do not get approved if they don't have fat and oil traps.

We have learned that there are many organizations involved in water provision, management, treatment, and infrastructure (DIWTS, NamWater, Department of Agriculture,

Water, and Forestry, city government and other related organizations). Who is responsible for what and how do you work together?

- The Namibian Government has different ministries; the DITWS is local government, so is under local government ministry. Under the local government act, they are required to have their own regulations on drainage, and these regulations are approved by the Water Office.
- The Water Office is under the Department of Agriculture, Water & Forestry, and they deal with water. The Water Office has the 1956 Water Act which controls water supply like NamWater, etc., but they're not sure if they have their own regulations.
- NamWater is water generation company, operated independently but managed by government; the city is buying water from NamWater… Windhoek is their customer.
- City of Windhoek has its own infrastructure, but they still get water from NamWater.

How should we go about determining the specific individuals to talk with when consulting with industries, city government, and the DEA?

- Lorraine will contact environmental commissioner (in charge of DEA), and he will know exactly who the people are we need to talk to. They work more broadly, they have pollution control and forestry section, and she will ask specifically for us to talk to pollution control personnel.
- The DIWTS only monitors industries within city.
- The DEA monitors the DIWTS and every industry in the country: if DIWTS wants to make a treatment facility, the DEA must check it.
- For industries, we will talk to operations managers for all interviews.

When visiting industries what indicates a strong effluent treatment infrastructure? What information is provided to the industry about pollution control and water treatment when constructing their business?

- With NamBrew, they are better than the others in water consumption side. They used to be 1:4 ratio; 1 L of beer produced uses 4 L of water. This ratio is one of the best of all industries.
- NamBrew's output water is good for the treatment. They don't need to treat before discharging…their COD was most the time around 1000, but they wanted to put in treatment plant to reduce that just for themselves so that they can reuse the water in their processes.
- NamBrew is a good example industry because, if you ask them, they monitor the water that they take in, that they use in the product, and that gets discharged. Other companies do not know this information.
- The other one that could be good is NeoPaint. They also monitor their water and product intake and outtake, but it all depends on what kind of paint they are making. They are also attempting to put in sieve and settling tank.
- Some companies like Nikara have made effort to put up a treatment plant, but their COD is still so high that they are still being charged a lot of money. It's a very good business, but they do not have good housekeeping because of the nature of the business itself. That is not an easy industry to manage.

When industries do not meet regulation for effluent treatment, what is the action that you take and the city takes? What are the general reactions from these industries? How effective is this action in causing an industry to comply better?

- When Kalimbo is on site and sees illegal disposal, he used to just warn them. They realized this not effective, and thus if he now sees illegal disposing, he issues a fine.

- If Kalimbo doesn't see effort towards correction, Lorraine then writes a letter to the company stating that they are exceeding parameters and are now illegally doing business. There are companies are then put on the DIWTS watch list, and some are using minimal water but polluting heavily. These industries pay a monthly fee for exceeding parameters.
- If they are not already on the list when found in violation (the poultry, NPIs,) they get one warning and the chance to respond to letter. If they do not get a response, DIWTS keeps pushing though they try not to close down industries. If communication is not happening, companies will have to be closed down.
    - For example the biggest textile industry in Windhoek (by DIWTS) and Namibia Tannery (by water office) was closed down because of no communication.

How are the regulations communicated to industries and are there any inefficiencies to communicating these regulations to industries?

- Meetings are scheduled to introduce the drainage regulations. All industries were called and/or meetings were scheduled when new tariffs for new parameters were introduced. Last year, before the new regulation was implemented, the relevant company personnel had meetings with the head of the department to give them advance notification. Those meetings allow the DIWTS to maintain consistent contact them, especially the ones on the "list". Drainage regulation is available to industries free of charge. They also know Kalimbo and his role.

We have researched the pollutants that you have provided to us and their effects on drinking water quality as well as water treatment processes. Are there any of these that are of greater concern than others?

- They all are being monitored, but depending on the type of industry, we don't monitor everything.
- Some industries have extra (for example heavy metals) depending on the type.

Do you ever have complications with solid waste from industries that is harmful to water sources?

- Most of the solid waste is handled privately. The city of Windhoek doesn't handle solid waste; each industry handles their own solid waste.
- *Kalimbo:* Sometimes, some companies will dispose solid waste (sludge, clothes, etc.) into a drain for wastewater, sometimes an employee who doesn't know
- From MeatCo, those solids are supposed to have their own separate tank. They have a contract with someone who comes and removes the waste.
- Sometimes, industries are not aware of the fact that settling takes three days. Some uneducated employees don't wait enough time for sludge to settle, they just open valves and release before sludge can be removed.

Are there any other factors such as pipeline bursts or infrastructure failures that result in pollution of water sources?

- *Kalimbo:* The problem there between us and the industries is that we only have a problem with kitchens of industries; if they use cooking oil and dispose of into pipe rather than properly, the oil cools and becomes solid and can clog pipes.
- Most sewers gravitate and are not pumped.

- When manholes get blocked, overflow runs off into rivers into Goreangab dam. If manholes don't have covers, the manhole can overflow or people can dump into it.
- Public vandalism is also a factor. Some people take covers off of drains to sell it because it is valuable cast iron. Efforts to develop new material that is lockable or not valuable are being worked on.

Is there any monitoring of industrial effluent records?

- Everyone does their own records. Only four are run by the city, and these four have online sampling and recordkeeping.
- Individual industries will not have records because they just started now, but the DIWTS can provide us with data from the inflow to the Ujams and Gammams.
- Compliance is determined by sampling and recording with new online system.
- DIWTS assumes that 85% of water gets discharged after manufacturing, which is a lot. Unless an industry can prove they are using less than 85%, they still will be in violation.
- The DIWTS does not charge for domestic use (such as restrooms in facility, etc.)
- Companies must provide specific data showing how much of water is discharged. NamBrew does this well.

Appendix C: Expert Interview Summary—Department of Environmental Affairs

Can you describe what your organization does? What do you do for this organization?

- The Ministry was created as a mandate of the constitution to protect and conserve residents and resources and to ensure that resources are used sustainably.
- The Ministry is made up of 3 departments: finances, natural resources (scientific services, parks & wildlife management, tourism), and environmental affairs (environmental commissioner).
- The departments are specially created to enact the Environmental Act which encompasses all institutions.
- The Environmental Department which he heads is responsible for new environmental regulations and compliance to these regulations.
    - They handle the legal framework in waste management and pollution control
    - This department is headed by the Deputy Director
    - They are currently busy drafting the Waste Management and Pollution Control Bill
    - Primarily ensure safe handling and disposal of waste
        - In Namibia, they have two Class 1 landfill sites and the rest are dumping sites.
- Handling of waste and pollution is scattered among many different organizations.
    - One day, he would like to have all under one institution (money, compliance, proper coordination/implementation of the law)
    - This will become possible once the draft bill is enacted with collapse of current system

What is your responsibility within the regulatory process of industrial water and waste management?

- Speaking about what he'd like them to be:
    - The Department of Water Affairs deals with effluent
    - The municipalities take on regulation and provision of water
        - Most industrial activities take place in the boundaries of municipalities, therefore they must comply to those regulations
- The current role of the Department in this regard is pretty minimal.
    - Can intervene in/close any institution which endangers environment
    - Can commission environmental audits

What are some of the major sources of pollution in Windhoek and what are the major effects of the pollution? What effects do the industrial pollutants have on the environment?

- In Namibia, the major source of possible environmental pollution is mining.
    - Mining is leading contributor to GDP
    - Mining is the biggest possible polluter with the chemicals they use
    - Mining technologies are undergoing major upgrades
- There is also a concern with chemicals used in agricultural sector.
    - Insecticides threaten indigenous species
- Fisheries are on the list of concern as well, but not until they grow in size.
- The city has limited industry at the moment.
    - National vision is to industrialize the country
    - They will be proactive to strengthen standards to deal with expansion of industries in Namibia
    - Most industries in the country are now in Windhoek or Walvis Bay

What have been the major environmental impacts of industrialization?

- Many industries will still prefer to be in Windhoek which poses problems for pollution.
    - Slaughter houses are of major concern in terms of the environment
- Industries that come to Windhoek must be sustainable in environmental and economical respects.
- Water will be the limiting factor in considering an industry capacity in Windhoek: the ones that use less water will likely thrive here.
    - Ramatex failed here because of this

What have been the major environmental impacts of urbanization?

- When the city grows, it is good!
- A disadvantage is that they generally have few people, and thus less money.
- It is also difficult to ensure that everyone has enough provided to them, especially with the amount of people moving here.
    - Jobs, shelter, education, other amenities must be considered
- He gives credit to city planners in respect to this trend, especially with the difficult way the city has been developed, especially in regard to water.
    - Water resources need to be protected though

Is there evidence that these phenomena have impacted the water supply in Windhoek?

- He wouldn't say that pollution has impacted the water supply.
- The city has the technological capacity to keep track of any possible threats to water sources; contamination/pollution are detected and picked up and addressed.
- There have been reports on possible contamination coming from the Tannery (northern part of Windhoek)
    - Thus a study was commissioned with Water Affairs, resulting in continuous monitoring of the effluent; suggestions were made and implemented via upgrades of the city.

What is the biggest challenge for your department in terms of the current water challenges in Windhoek?

- "Wish we could make the rainfall rain?"
- The biggest challenge is to manage the demand and to accommodate industries that will stimulate the economy to grow.
    - We can't allow industries to come that we would like to have due to stress on water system.
- Monetary challenges are also a large part of the issue.
- Windhoek is the first city to store underground water…the challenge is to be able to innovate to maintain infrastructure and provide residents and industries with sufficient amount of water.
- There is also a challenge to establish and maintain water infrastructure, maintain water reserves (dams), and maintain reclamation plants.
    - Everything, when it rains, ends up in Goreangab dam
- The city is growing in number of small and medium industries (encouraged)
    - The government has policy that supports small business establishment
    - This is great for the economy, but poses threats to environment, especially in terms of discharge of oil (panel beating) and paint

  - There is a need for policy to expand to be accompanied by strategy; policy to avoid detrimental effects to the environment

We have studied some of the proposed options for expansion of Windhoek's water sources. Are there any viable options for expansion of Windhoek's water supply?

- We have dedicated a whole ministry for that.
- NamWater is responsible for exploiting new sources and ensuring long term supply to the residents of Namibia.
- We are looking at desalination and the Okavango River.
  - All rivers are shared, therefore we have to do withdrawing with consultation
  - Desalination is the most long-term solution, but it requires significant monetary investment

Appendix D: Expert Interview Summary—Water Affairs

Can you describe what your organization does? What do you do for this organization?

- *Matthew:* Hydrologist in the DWA. Their section is Water Environment (there are 4 other divisions). The water environment section deals with pollution control and water monitoring issues.
    - Specific roles: to conduct compliance visits of local industries that generate wastewater and check that complying with permits.
- *Ivondia:* At the moment, there are two acts which they currently operate under
    - One is the 1956 Water Act that is inherited from South Africa. It is now not able to be enforced.
    - The other is the new, "namibianized" water act called the 2013 Water Resource Management Act. It has not commenced yet, but has been used during inspections so people can get used to it. It will be commenced this year. Currently, they cannot take industries to court with it yet, but once it is commenced they will be able to.

What is your responsibility within the regulatory process of industrial water and waste management? How are your regulations communicated to industries?

- The City of Windhoek has their own specific regulations and conditions for industries operating within their jurisdiction. They will be the ones to go and inspect to see what they're doing.
- The DWA goes on their own or with the city. The law administration is actually supposed to enforce and inspect but they don't, so the DWA goes. They believe this is simply because of who is available and who has the time.
- The DWA checks permits and performs sampling (raw and effluent) to see whether treatment is working or not. The 1956 Water Act is not specific to violations of compliance, and many times regulation ends up being more dialogue with industries.
- *Kalimbo:* If the city gives a permit to industries and they later on do not meet standards, they don't renew the certificate of business until changes are made.
- You can withhold permits, but they cannot tell them to stop operating, so essentially this process is not effective.
- *Matthew:* I deal with the mines, which are now more than ever becoming big industry. Permits are a pollution control mechanism, while another objective of permits is to look at water demand of company and to encourage industries to practice water saving & reuse measures.

How does the city project estimates for the yearly water consumption, both industrial and municipal? Has this yearly consumption ever been exceeded? What occurs when this happens?

- That would be NamWater, they were the ones to investigate water supply.
- Geohydrology division would know the aquifer information hydrology would know surface water, etc. We don't have comprehensive answer.
- Currently they allocate certain amounts of water to farmers and big industries and whenever an institution feels that the amount won't be enough, they can make a request for additional cubic meters to be allocated to them.
- They have to submit returns every year to re-allocate the water amount.

What do you do to monitor and control the water consumption of industries? Are industries generally consuming acceptable amounts of water?

- We don't really monitor consumption because meters are under city's jurisdiction; we regulate the whole country, not just Windhoek and the city boundaries are under local authorities.
- In terms of bulk water supply, NamWater is sort of an arm of the ministry, and the DWA verifies every now and then that the water NamWater is distributing is of good quality.

What are the major challenges that you see with industrialization for water sources?

- It is largely a political matter, as the water technologists don't want water heavy industries to establish in the city.
- There are five resources for water: three surface water dams, reclamation plants, and the aquifer boreholes.
- Industrialization within Windhoek is not advised due to challenges with pollution.
- Industries are improved without DWA knowledge.
    - eg. A chicken farm established and set up treatment plant. Now they don't have specialist who knows what is what, so when the DWA goes to learn about it, the person on site does not know what's happening to the waste. All they care about is the production of chicken, they do not care about their waste.
    - This happens a lot with the northern industries that are not connected to wastewater treatment plant. They often don't have treatment facilities, they just have holding tanks which need to be pumped, but often they aren't and they overflow.
- The main problem industries are ones that are not directly connected.
    - The tannery near Okapuka was established a long time ago. They were polluting when they started but now the whole area is a mess. They are understanding and have been attempting to improve their system. They understood their effect on the environment, and they have monitoring boreholes.
- Some industries are truly cooperative, while some see the DWA/city as the bad guys.
- This will only improve when we do public awareness surrounding the new act because they will understand the impact and the importance.
- Within the government, there are three ministries that have to work together on water related issues: Ministry of Agriculture Water and Forestry, Environment and Tourism, and Trade and Industry.
- Sometimes Trade and Industry approves new companies without following procedures of checking with DWA: they're supposed to give a presentation to DWA, but communication between industries is slow or nonexistent and they only come to you when there's a problem.
- Sometimes even the city fails to involve DWA for industries within their jurisdiction.

In terms of the current water supply, what actions do you feel need to happen in the foreseeable future in order to ensure that Windhoek residents and/or industries are consuming sustainable amounts of water? (for example, water rationing, dry industries, etc.)

- There's little awareness in our country, especially in Windhoek. There was a time when we were doing something with students, asking them if they understood that Windhoek uses reclaimed water, and some had no idea. People should know what water they are drinking…some people don't even know there's water scarcity in Windhoek.

- Before rationing, you should tell people about the problem so that they can do something about it. Hopefully this can be addressed at the basin level. The awareness campaigns will be huge.
- Rationing should be put in place already, even with just showers for a certain time.
- Windhoek's aquifers can store more; the reclamation plant can produce more, but there are financial constraints. That won't be the only way because the dams are running dry.

We have studied some of the proposed options for expansion of Windhoek's water sources. Are there any viable options for expansion of Windhoek's water supply?

- We are not responsible for water supply. The new water act has a basin management committee that is to be established. Windhoek is in the Swakop Basin.
- Within the upper Swakop management basin, all stakeholders are coming together to look at problems and what remedies can be done. So far they are working; the Upper Swakop is the last committee to be established, so hopefully now these will help.
- Most industries, especially big ones, will know what water they are using. Namibia Breweries uses reclaimed water & surface water, other industries only use NamWater piped water.

When will the 2013 Water Resource Management Act start being enforced?

- They are waiting for different divisions to compile regulations for the act (supporting documents for the act). That is their current directive.
- The directives should be in place by August and the act should be implemented towards September.
- The Policy & Law division will be the one to implement it, and the DWA has expressed that they need it to be implemented.

When industries do not comply with regulations, what is process that takes place? And time the frame?

- You have to deal with politicians in Africa… there are some industries we could never shut down.
- It all goes back to the act again.
    - Right now: If there are irregularities with industry, a report of the findings is compiled, and a letter will be sent to a high office of ministry. This letter will then go to industry, at which point they will send a message back describing program of action. Other than dialogue, there is not much they can do. Currently there is more dialogue, but there was an incident where a colleague communicated with an industry but there was no improvement. She referred case to a body who can transgress punishments, such as court or fines, but this takes a long time. With certain industries, such as mines, they don't want to get to that extent. They are sometimes subject to environmental audits, and most of the time they quickly act on it because their water permit is connected to their environmental audit.
    - When the new water act is commenced, all industries will be given 1 year to make changes before they can begin to punish people for noncompliance.
- When the act is implemented, it will impose some fines if action is not taken in a given timeline. In this act, the standards and regulations clearly state what happens if someone does not comply.

There's a lack in communication within the ministries and city: What would you recommend to improve communication?

- When systems are to be put up anywhere in the country, the first step needs to be a proposal for business to the DWA. That is not happening, and systems are being put up without their knowledge. That is when there are problems.
- They would like a channel of communication that begins with the DWA.
- There is a nice platform called the Water and Sanitation Forum. This is where communication should start: all ministries that deal with water are a part of the forum. The ministries we want to support are not part of the forum (they are not represented at forums). When someone from that ministry does come, it is not a knowledgeable person. It's not fully representative.

Previous water perception campaigns: how were they initiated or administered? Via the school systems?

- The only campaign that this department did is through called World Wetlands and Water Day. They combine the 2 days and commemorate in 1 day/week: March 22nd-27th.
- The theme is around preserving water & wetland. They go to wetland in Namibia and commemorate it on that day.
- This is done based on each basin, and teachers from each school are included.
- Back in 1996 or 1997, the city had campaigns to do with water demand management to encourage citizens to use water wisely in a pamphlet or newsletter form.
    - Awareness should involve school children and communities that are more rural.
    - It would be good if it was implemented as a school subject in the curriculum.
    - For industries, we would invite them to workshops.
    - For industries, the city is doing a good job. They are paying for their use and discharge, so they are aware of it to some degree. It is the community who doesn't know.
- In schools for World Wetland Day, they should implement an assignment such as produce a poem or produce a song about water management or something.
- The challenge they have picked up within local authorities around the country is that too much water is lost in distribution system. Local authorities should upgrade their systems so that they do not lose water and need to seek other sources.
- A challenge with industries managing own waste water treatment plants is that unskilled people are running the plants. There should be a person responsible for running the treatment plant who knows how to operate it. Sometimes spillage or overflow happens simply because person does not know how to operate system.
- In regard to the dams:
    - The ministry does not have control over the dams, it is just city of Windhoek
    - Despite this, the dams are one of the TOP topics for the upper basin committee
    - NamWater pumps water from two dams to the Von Bach. There is a treatment plant at the Von Bach, but there is no pretreatment before meeting the Von Bach.
    - There is investigation into treating water at Swakopport before moving to Von Bach.
        - The main address should be in Windhoek as the pollution of Swakopport is coming from Windhoek
    - Pollution in the dams is a symptom, not a cause. The DWA knows cause, and needs to find a solution.
    - The Goreangab is upstream of Swakopport and is always overflowing to Swakopport
- In regards to artificial recharge:

- It is taking place, and has been since 2009
- When there is a high water supply is when recharge occurs. During low water supply is when it is withdrawn
- Infrastructure is there to recharge, but the capacity must be increased
- There was an Artificial Recharge Committee (died down in 2013)
- There are complications between NamWater and City
    - The city says that the quality of the water in the aquifers is not good enough
    - NamWater says that they are supplying water to city, so why isn't the city recharging?

Appendix E: Site Visit Notes from Water Reclamation Plant Tours

Ujams Water Reclamation Plant Site Visit Notes

- Catchment area if from the northern industrial sector which includes animal farming, breweries (highest contributors), canneries, and mechanical effluent.
- Additionally, there is a lot of agriculture around the plant.
- The inflow is split into two tanks to preserve the machinery lifetime.
- The flow moves through an inlet into a compactor where the biggest components are removed.
- The water then flows to a separation tank where it is rinsed with surface water and vortexed, removing sand and other non-homogeneous particles.
- The supernatant flows into a channel while the dry components are filtered out (700 micron filters).
    - In order to recycle the most water, the dry component travels through a spring loaded plate where more water is recovered and dry waste is pushed out and collected for removal to the land fill [removes some COD in the process].
    - The filter/membranes are the "babies" of the plant, taking the most effort to maintain.
    - They test the flow of the supernatant into the channel by sampling every $50m^3$
        - These samples are used during contract negotiation.
- Some of the chemicals they use to then treat the supernatant are:
    - Ferric chloride ($FeCl_2$) to treat phosphates
    - Hydrochloric acid (HCl) and citric acid for pH stabilization
    - Potassium hydroxide (KOH) to clean fine sieves
    - Etc.
- If they see a spike in any component while testing and treating, it is generally suspended solids [increases COD].
    - The goal is to remove the most COD as possible.
- The treated water then moves to another tank with a depth of 6.0M. With an effective depth of 4.1M, any overflow going directly to the river that eventually could travel to the Swakopport dam 300kM away where it would then be treated/distributed by NamWater (not an ideal situation; generally only occurs during the rainy season if it does at all)
- The water flows to an aerating tank (air is treated afterwards with a biological process for the odor) to maintain the correct redox potential.
    - In this tank, the water is agitated to keep the components suspended.
        - To clean this, they use water from the Von Bach dam.
- The water then flows into agitating ponds (6.0M in depth) where it undergoes denitrification and nitrification processes
    - Ammonia is separated into nitrogen/phosphorous.
        - A good indicator of effective filtration.
    - In this stage, the flocculation (foam) settles on top of the water, while the sludge settles on the bottom.
        - Sludge is removed, mixed with a polymer, and run through a belt presser to remove as much water as possible (6% dry-14% dry). The sludge is removed to a landfill while the water enters the start of the treatment process.
- The final filtration of the water is at a level of 0.45 microns with a pressure of 7 barr, the barrier between soluble and insoluble compounds in water, after which it is treated with U-V light to disinfect it.
    - U-V light kills bacteria and other pathogens so they are not able to reproduce.
        - Don't treat with chloride due to the harmful byproducts that may occur.

- The water then flows into a water storage tank (filled to 85% always for firefighting purposes)
- The designed rate of flow out of the plant per day is 5ML. The plant is small but is it state of the art, especially compared to the previous system which was simply oxidation ponds.
- In the event of a power outage, they have a 900L tank of diesel.

- The plant only pays to remove dry waste once a month while the sludge has to be removed about twice a day to 20km away. All the water and sludge that comes out of the plant belongs to the city.
- Pharmaceuticals are becoming more common in the effluent but are lacking in treatment.
    - For every new contaminant, a method for testing and treatment must be developed.

- Quotes:
    - The government practices "selective enforcement" of the effluent regulations.
    - On water reclamation… "It's really a perception thing. People don't complain as long as water comes out of the tap."
    - "The Von Bach will always be polluted until there is a monitoring system for it."

Gammams Water Care Works Site Visit Notes

- There are three inlets by which domestic effluent comes to the plant which was established in 1961.
- Water is treated with all biological processes [A & B series treatment]
- Water first flows through mechanical screens to remove solid waste (ex. Paper, plastic, etc.). The solid waste is moved to the skip where it eventually is burned.
- The water flows into degrading vortex tanks. The sand settles into the bottom of the vortex, separated from the water, and transferred to the landfill.
- The water flows into seven primary settling tanks for removal of 30-40% of organic material. The sludge settles to the bottom of these tanks.
    - Sludge is then treated with anaerobic digesters to remove further organic material, releasing carbon dioxide and methane (looking to harvest methane for energy).
    - Sludge also treated with hot digesters to adjust the pH/alkalinity [currently a cold process] and sent to drying beds (solar heating).
    - Dry matter goes through a belt presser to remove as much water as possible (1-5% dry to 20% dry).
        - A private contractor harvests dry matter, neutralizes it and uses it for agricultural purposes.
- That concludes the steps of the "Primary Treatment" which essentially sets up the water to have the lightest load on the MBR.

- The settled water flows to the conventional activator sludge pump where it is treated by various different processes including:
    - An anaerobic zone for phosphate release (causes algae and eutrophication)
    - Denitrification for the removal of nitrates
    - Nitrification for the breakdown of ammonia
    - Etc.
- The water flows through an additional filtration process for organic stripping and further nitrification before moving onto the secondary clarifiers to remove any additional sludge to be recycled back into the reactor.
- The water then flows into maturation ponds for pathogen removal (Chloride?) where is it discharged into the river and flows to a central station where it is distributed to Windhoek.

- The plant has very old tanks which they are going to refurbish.
- The plant is currently operating at 25-27ML per day, while the current capacity is bout 14ML per day.
- Currently, the level of COD and suspended solids are quite high.
- During winter, the plant has a hard time complying with acceptable nitrogen levels in the potable water.
- Overall challenges:
    - Infrastructure over capacity
    - Maintenance of the plant
    - The knowledge needed to work in this field is very specialized, making it very hard to maintain knowledge/expertise

Gammams Laboratory Site Visit Notes

- They receive industrial effluent samples as well as reclaimed water samples.
- In testing these samples, some of the testing processes include:
    - Physical properties
        - Organic matter
        - COD
        - Dissolved oxygen
    - Conductivity
    - Temperature
    - pH
    - Color
    - Organic Carbon Analysis
    - Ion chromatography for inorganic samples [used for potable water]
        - Anions: chloride, fluoride, phosphate, etc.
        - Cations: sodium, potassium, magnesium, etc.
    - Alkalinity [for waste water]
    - Continuous Segment Flow Analysis
        - U-V Colorimetric method
- They also have a microbiology department of about 7 people that they are applying for accreditation for. This department is responsible for the testing of potable water and sometimes sewage.
- The major technique used in their testing processes is membrane filtration (48 hours per test).

Wingoec Water Reclamation Plant Site Visit Notes

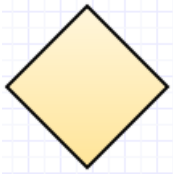
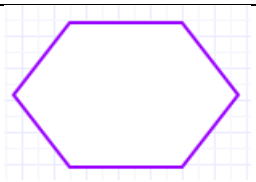
Representative: Siegfried Mueller

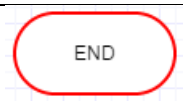
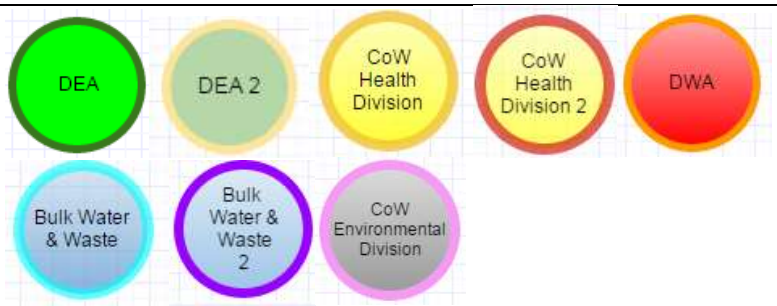
- The plant is treating heavy amounts of industrial effluent from the northern industrial sector
    - Within treatment, bromides are a component of the effluent that poses to be the biggest issue for them (investigated in last year's IQP)
- The effluent travels to the plant via gravitational flow
- The plant utilizes a multi-barrier approach which the forefathers of the reclamation movement are responsible for pioneering
- The Wingoec plant is designed for a capacity of 24ML per day into the plant and 21ML per day out of the plant
    - The water is eventually treated via chlorination (1mg/1L) to treat water borne diseases
        - This practice is still highly debated among the water treatment stakeholders
- After the water is treated, it is pumped to Windhoek where NamWater will blend it in a 1:2 ratio
- Problems that the plant encounters are:
    - Dam encroachment
    - The Old Goreangab Dam used to be used as part of a two pipeline approach to supply households with water; one pipeline would have potable water while the other would have semi-purified water to be used for irrigation, clothes, etc.
        - People tried to cheat the system by using only the semi-purified to save in price, but would end up sick
        - Now only one pipeline of potable water is supplied to households, which has driven up water use
- Propositions for the current situation in Windhoek:
    - The city will (and is) implement higher tariffs for water usage
        - This is generally quite effective but only within the city, as water and energy are the main sources of income
    - In the long-term, the city will have to look into expanding its water sources using the Okavango Delta via the Omatako Dam and/or desalination
        - Both of these would increase the cost of water

- Direct quotes:
    - "Water quality in Windhoek is not the same as you will find everywhere in Namibia."
    - "You can implement many things, but the problem is really control."
        - Eg. Three step drain systems for industries
- Final notes:
    - Their ultimate goal is to provide quality water. They would ask in return that industries monitor their water (using the systems in place), thus making it cheaper to treat water, and lowering the price of water overall

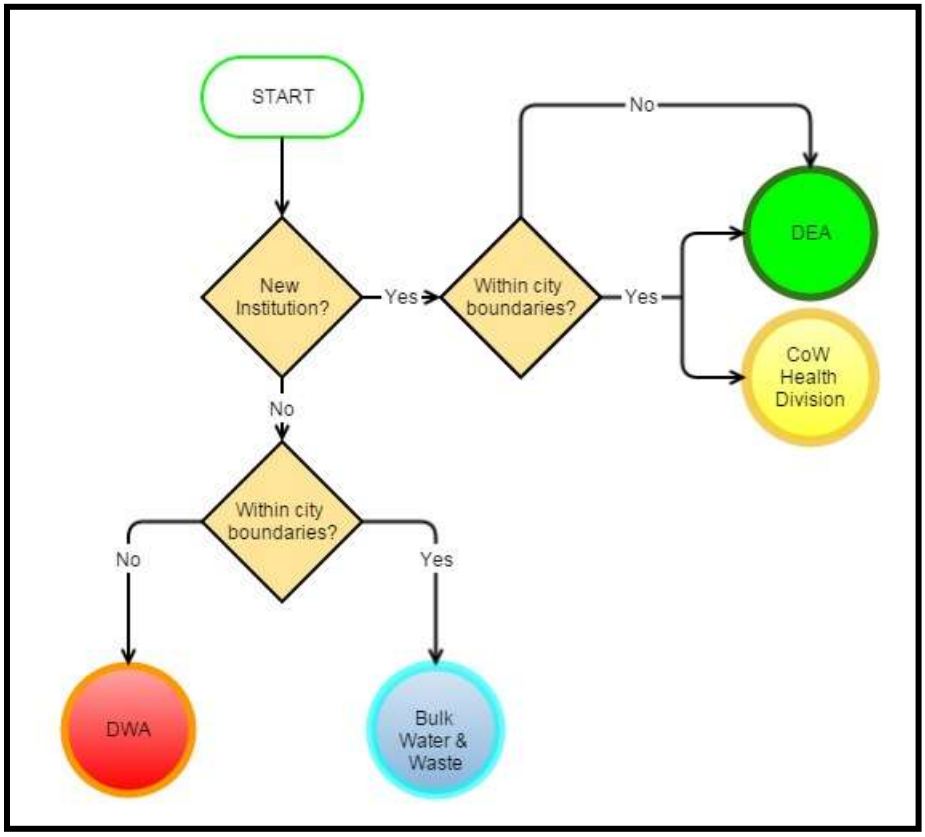
Appendix F: Flowcharts of Industrial Permitting Process and Water & Waste Management

FLOWCHART KEY

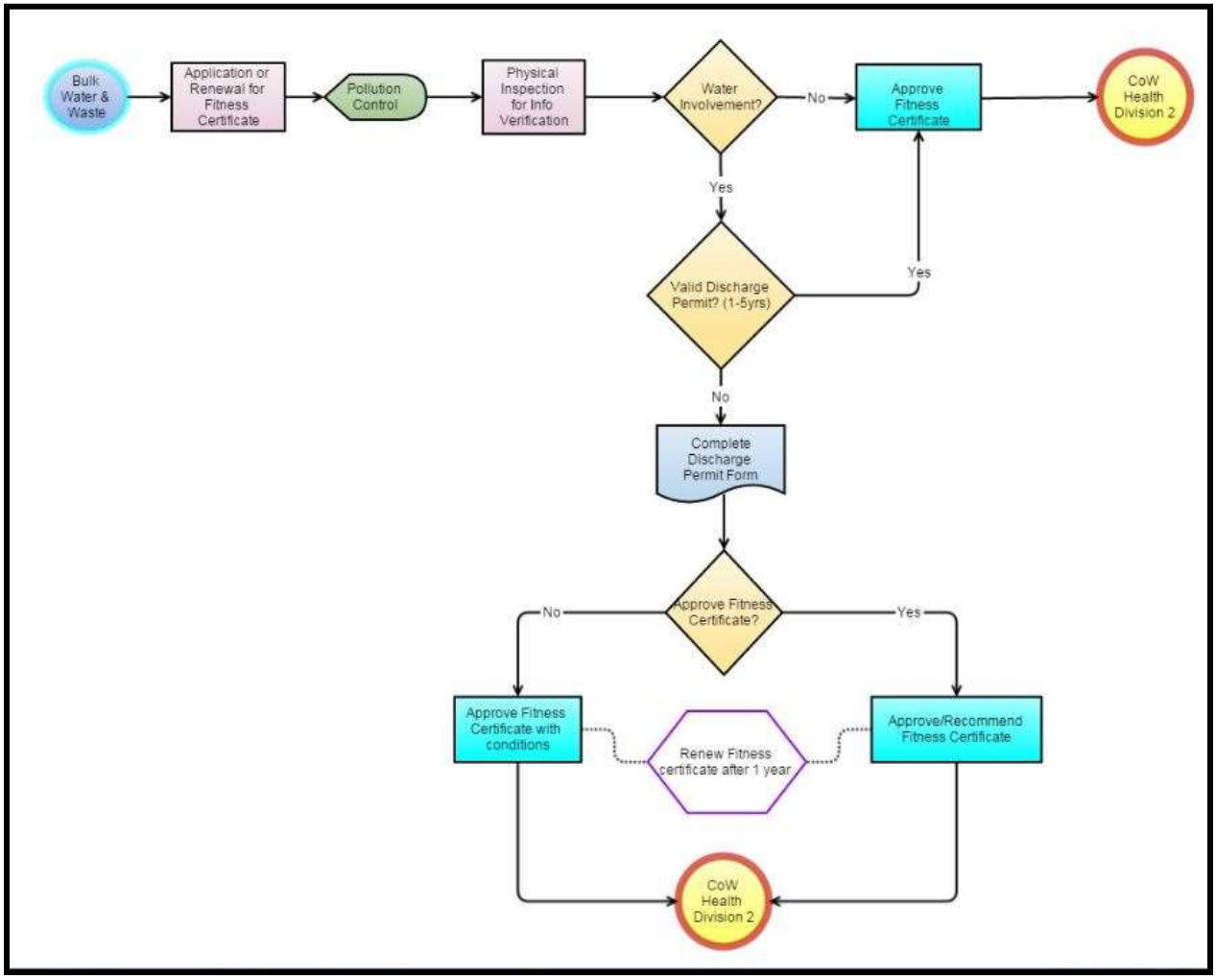
	Document is issued or approved by a department
	Specific sector within a department or organization
	A process within the regulatory party
	A decision has to be made
	Documentation is provided or submitted
	Documents or notifications are sent to other departments
	Predefined process or program
	Pollution control and compliance monitoring program
	Specifies the time of validity of a permit or certificate
	Identifies the start of a process

	Identifies the end of a process
	Multiple documents from different sources
	All City of Windhoek departments
	Indicates start of a specific process
Start of processes in pertinent departments	
Abberviations	DEA – Department of Environmental Affairs DWA – Department of Water Affairs CoW – City of Windhoek EIA – Environmental Impact Assessment

a) START OF BUSINESS CERTIFICATION PROCESS

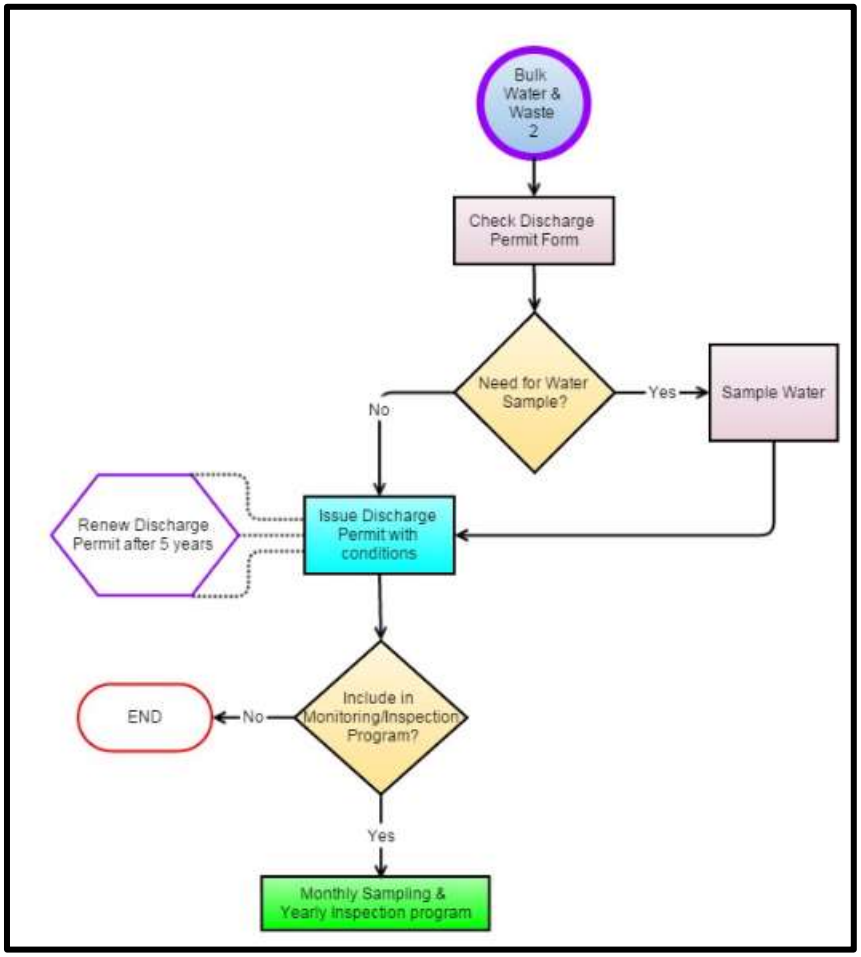


b) DIWTS BULK WATER & WASTE FITNESS CERTIFICATE APPLICATION/RENEWAL PROCESS



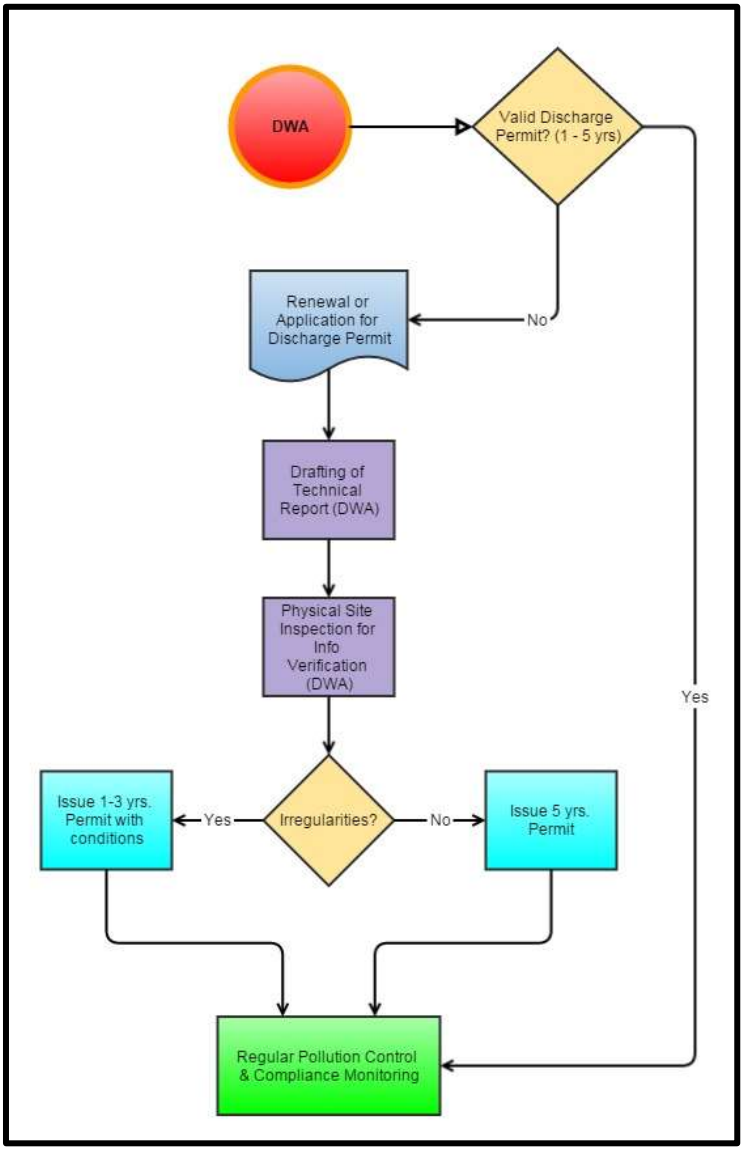
Inefficiency: The Fitness Certificate is always approved whether with conditions or not.

c) DIWTS BULK WATER & WASTE FITNESS CERTIFICATE APPLICATION/RENEWAL PROCESS



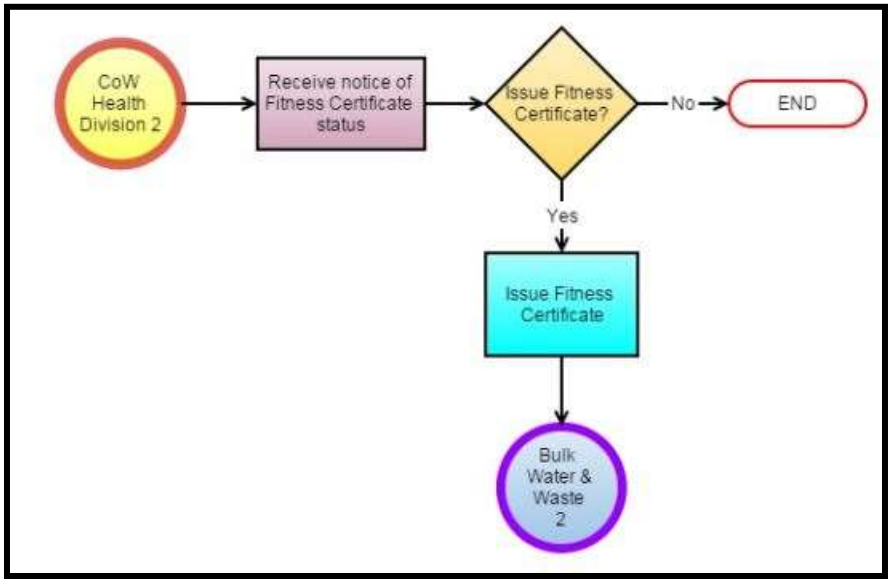
Inefficiency: After a company has obtained a Discharge Permit, they are renewed automatically (Hence growing industries are left unregulated).

d) DEPARTMENT OF WATER AFFAIRS DISCHARGE PERMIT APPLICATION/RENEWAL PROCESS



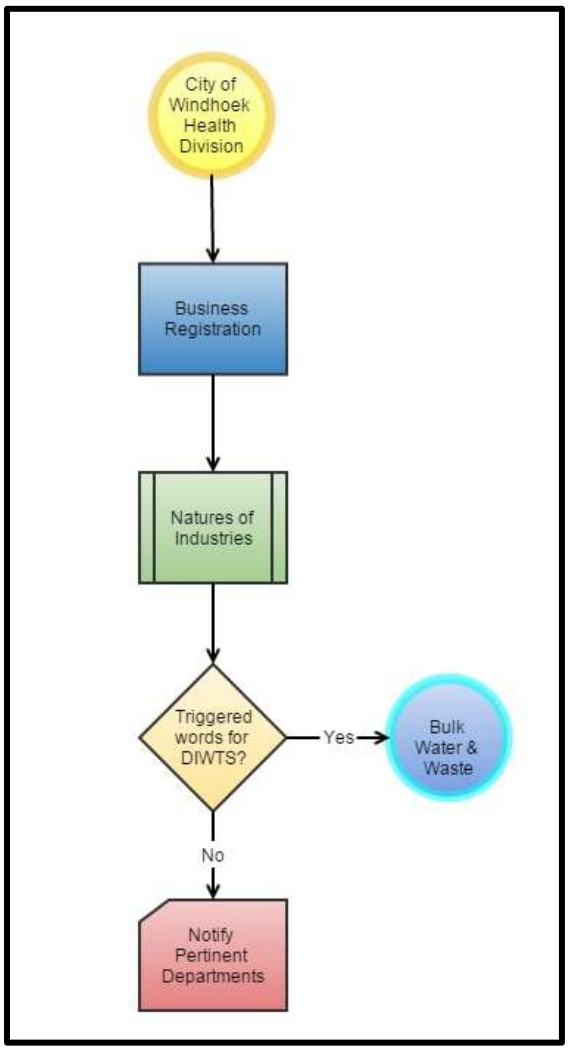
Inefficiency: The Discharge Permit is always issued whether with conditions or not.

e) CITY OF WINDHOEK HEALTH DIVISION FITNESS CERTIFICATE PROCESS



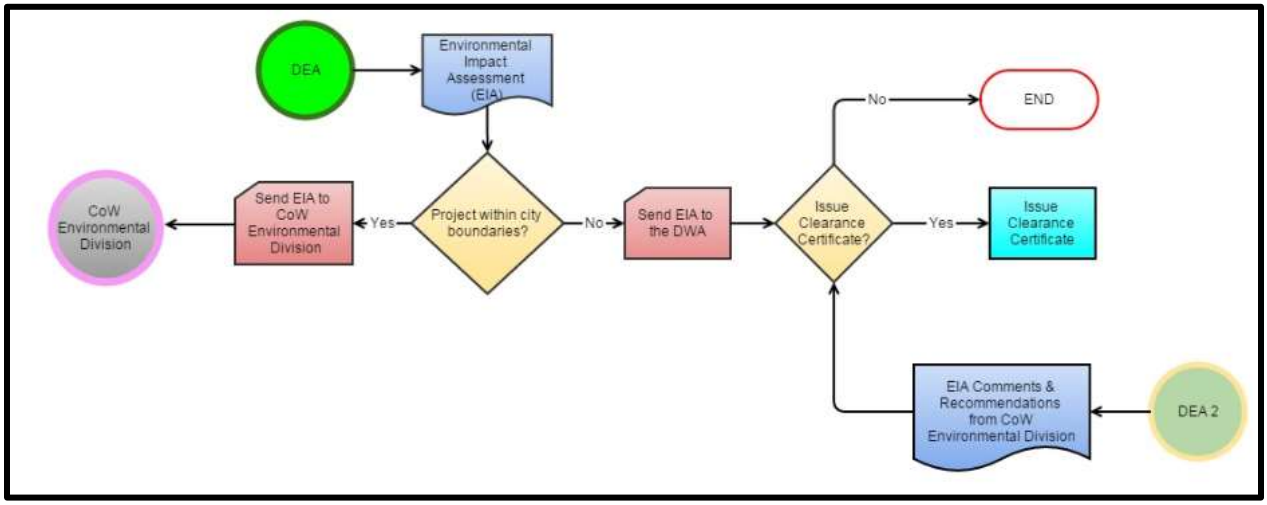
Inefficiency: None identified.

f) CITY OF WINDHOEK HEALTH DIVISION DEPARTMENT BUSINESS NOTIFICATION PROCESS



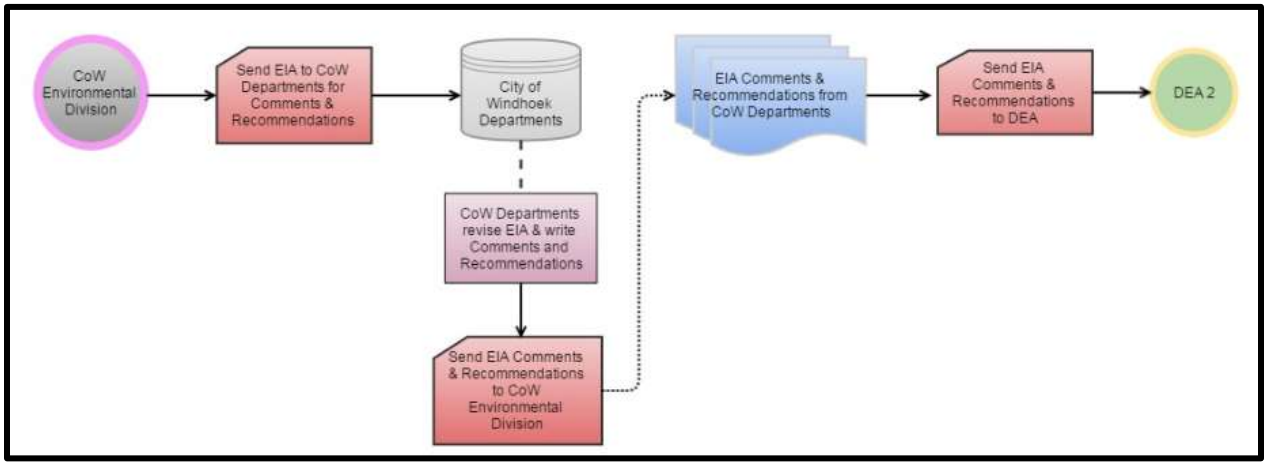
Inefficiency: Pertinent departments are not notified throughout the process.

g) DEPARTMENT OF ENVIRONMENTAL AFFAIRS CLEARANCE CERTIFICATE PROCESS



Inefficiency: Pertinent organizations/department are not always notified.

h) CITY OF WINDHOEK ENVIRONMENTAL DIVISION EIA COMMENTS & RECOMMENDATIONS PROCESS



Inefficiency: EIA is not always sent to pertinent city departments.

Appendix G: Acknowledgement of Written Consent Form

Interview Confidentiality Agreement

This consent form outlines my rights as a participant in the study conducted by the City of Windhoek Department of Infrastructure, Water, and Technical Services in conjunction with Worcester Polytechnic Institute, USA. This interview will explore the topics of industrial water and waste management in the current regulatory environment. The interview will take approximately one hour.

I understand that:

1. Taking part in this study is entirely voluntary.
2. It is my right to decline to answer any questions I am asked.
3. I am free to end the interview at any time.
4. I may request that the interview not be recorded.
5. My name and identity will remain confidential in any publications or discussions.
6. My name will not appear on any recordings or transcripts resulting from this interview.

By signing your name below, you agree to the following statement:

"*I have read this consent form. I have had the opportunity to ask questions concerning any areas that I did not understand.*"

_____	_____
(signature of interviewee)	(signature of interviewer)
_____	_____
(printed name of interviewee)	(printed name of interviewer)
_____	_____
(date)	(date)

You may decline to participate in this study. You may end your participation in this study at any time. Maintaining your anonymity is a priority and every practical precaution will be taken to disguise your identity. There will not be any identifying information on recordings or transcripts of this interview. We will not allow anyone other than the research advising personnel to hear any recording or review any transcript of this interview.

Appendix H: Oral Interview Outline for Industry Operational Managers

1. Introductory segment

- Introduction: To open, we just want to tell you a little about us and what our goals are for this interview. We're working on a project with our university from the United States. Our project goal is to gain an understanding of challenges Windhoek industries may encounter and how industries can be better supported to achieve regulatory compliance with water and waste management. By conducting interviews at various industries, we will be able to make recommendations to pertinent organizations regarding the effectiveness of the regulatory environment. Any information you are willing to provide will help us to accomplish this goal and will be used for the sole purpose of informing our further research. We will keep all information confidential from this interview. Do you have any thoughts or questions before we start? … Is it okay if we record our conversation?
- Consent form: *see appendix G*

2. Background:

- What major challenges does the city face with water scarcity, especially considering the current drought?
- Which solutions would you support to alleviate the water scarcity problems in Windhoek? (water rationing, mandatory water-saving devices)
- We are interested in knowing what you do as a company; can you tell us a brief background of what you do?

3. Regulations

- In terms of regulations, how accessible are they to you? How could they be better communicated to you?
- What are the major motives for (*company name*) to comply with the regulations?
  - 1956 Water Act and the 2013 Water Drainage Act?
- What are the main challenges (*company name*) faces when attempting to meet regulations? (specifically regarding effluent management and waste disposal)
  - How have those challenges been addressed in the past and currently?
- Can you think of any ways that the city better assist (*company name*) in compliance to regulations regarding water use and effluent production? What support does the company need?

4. Water & Waste Management

- Can you tell us a little bit about how the company monitors or keeps track of water consumption?
- Do employees receive any training or information regarding water use and conservation upon being employed?
- Have Windhoek's water shortages affected the company's operations?
  - Do you practice any water saving measures within your company?
  - Which solutions would you support to alleviate the water scarcity problems in Windhoek? (water rationing, mandatory water-saving devices)
- What materials are generally used to manufacture your product(s)?
- What materials are typically disposed of in your effluent at the end of the production process?
  - Is this effluent treated before disposal? If so, how?
  - Are there different processes for different types of waste?
- What are the known effects of *[the specific components of the effluent]*?
  - On human health? The environment? The reclamation system?

- What are some of the recommended best practices for effluent & water use that the company has implemented or hopes to implement in the future?
- What are some of the recommended best practices for effluent & water use that the company has implemented or hopes to implement in the future?

5. Conclusion

Appendix I: Company/Interviewee Interview Summary

This content has been removed due to confidentiality.

Appendix J: Company/Interviewee B Interview Summary

This content has been removed due to confidentiality.

Appendix K: Company/Interviewee C Interview Summary

This content has been removed due to confidentiality.

Appendix L: Company/Interviewee D Interview Summary

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Appendix M: Company/Interviewee E Interview Summary

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Appendix N: Company/Interviewee F Interview Summary

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Appendix O: Company/Interviewee G Interview Summary

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Appendix P: Company/Interviewee H Interview Summary

This content has been removed due to confidentiality.

Appendix Q: Company/Interviewee I Interview Summary

This content has been removed due to confidentiality.

Appendix R: Company/Interviewee Summary

This content has been removed due to confidentiality.

Appendix S: Company/Interviewee K Interviewee Summary

This content has been removed due to confidentiality.

Appendix T: Oral Interview Outline for Informal Industry Operational Manager

1. Introductory segment

- Introduction: To open, we just want to tell you a little about us and what our goals are for this interview. We're working on a project with our university from the United States. Our project goal is to gain an understanding of challenges Windhoek industries may encounter and how industries can be better supported with using water and properly disposing waste. By conducting interviews at various industries, we will be able to understand the challenges that various industries are facing. Any information you are willing to provide will help us to accomplish this goal and will be used for the sole purpose of our research. Do you have any thoughts or questions before we start?
- Is it okay if we record our conversation?
- Survey plans: In addition to this information, we'd also like to distribute some surveys (unrelated to industrial practices) that are about water topics in Windhoek. These are for us to assess the effectiveness of the city's awareness campaigns. After this interview, would you be able to help us distribute these to employees to fill out?
    - If not, alternative plan?

2. Background:

- What major challenges does the city currently face with water scarcity?
- Which solutions would you support to alleviate the water scarcity problems in Windhoek? (water rationing, mandatory water-saving devices)
- We are interested in knowing a little more about your company; can you tell us a briefly about what you do here?
- What are the main challenges that your company faces with operating in Windhoek?

3. Operations

- Where are you receiving your water for the operation of your company?
    - How are you being charged for your water use? (billed by the city?)
- Is the water consumption monitored or recorded here?
- Are employees encouraged to conserve water during operations?
    - Do you practice any water saving measures within your company?
- Have Windhoek's water shortages affected your company?
- Do you know what materials are disposed of in your wastewater?
    - How is the waste disposed of?
- Do these materials have an effect on the water that is recycled to Windhoek? (potentially on the rivers/drinking water)
- Are other companies similar to yours treating their wastewater before disposing of it?
    - Do any of these companies have ways in which they conserve water?
- What is your relationship with the city government? (regulated by the city?)
    - Do you know of the city regulations for water use and wastewater disposal?
    - (If yes) Do these regulations have any impact on your company?
    - (If no) Would you be interested in communication from the city regarding these regulations?
- Can you think of any ways that the city can better support the company?

4. Conclusion

Appendix U: Table of Codes for Industry Interview Analysis

CODE	DEFINITION
ABILITY TO OPERATE	Interviewee expressed the importance of the company's ability to operate
ACCESSIBLE REGULATIONS	City's regulations are accessible to industries
ACTIVATED SLUDGE	Company's effluent is treated by activated sludge
BATCH REACTOR	Company's effluent is treated by batch reactor
CITY INFRASTRUCTURE	Interviewee described problems with city infrastructure
COMMUNICATION SHOULD IMPROVE	Communication with city should be improved
COMPANY GROWTH	Interviewee described company growth
COMPANY VALUES	Interviewee described company values
COMPLYING TO REGULATIONS	Interviewee expressed that the company is complying to regulations
CONSUMPTION ANALYSIS	Company performs monthly analysis of water consumption
CONSUMPTION INCREASE	Total water consumption has increased since establishment
COOPERATION BETWEEN CITY AND RESIDENTS	Interviewee described a need for greater cooperation between city and residents
CORPORATE RESPONSIBILITY	Interviewee expressed the company's interest in sustainability within operations
COST	Interviewee discussed costs to the company
COST INVESTMENT	Interviewee described burden of cost investment
DEMAND INCREASE	Demand for company's service or product has increased since establishment
EFFLUENT AWARENESS PROGRAM	The interviewee expressed the need for an effluent awareness program by the city
EFFLUENT NOT TREATED	Company's effluent is not treated
EMPLOYEE HABITS	Interviewee described challenges to water conservation with employee habits
EMPLOYEE KNOWLEDGE	Interviewee described challenges to water

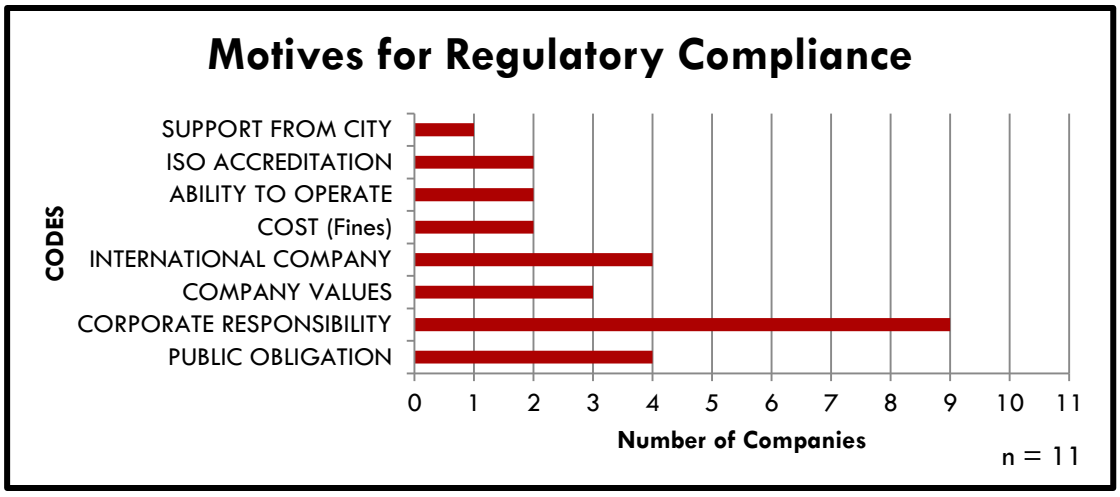
	conservation with employee knowledge
EVAPORATION POND	Company implemented evaporation pond(s)
FAT TRAP	Company implemented fat trap
FEEDBACK	Interviewee expressed a desire for more feedback from the city
FLAWED ENFORCEMENT	Interviewee expressed flaws in the enforcement of regulations
FLAWED REGULATIONS	Interviewee expressed flaws in the city's sampling and billing procedures
FLAWED REGULATIONS	Interviewee described flaws in regulation system
FOREIGN DEPENDENCY	Company is dependent on foreign organizations to operate
GENERAL PUBLIC KNOWLEDGE	Interviewee described challenges associated with lack of general public knowledge of water issues
HARD COPY NOTIFICATION	Notifications from city come in the form of mail
HIGH EMPLOYEE TURNOVER	Company faces challenges with high employee turnover rate
HIGH WATER USE	Interviewee described that the company uses high quantity of water
IMPROVED COMMUNICATION	Communication with city has improved
INCREASED WATER EFFICIENCY	Company has increased water efficiency
INTERNATIONAL COMPANY	Company sells, exports, or is partnered with other organizations internationally
ISO ACCREDITATION	International Standards Accreditations available to industries
LACK OF CITY INTERACTION	Interviewee described importance of greater interaction with city
LACK OF EXPERTISE	Interviewee described the challenges with a lack of expertise in the company
LACK OF TRAINING PLAN	Company lacks plan or personnel for training program
LEAKAGE	Interviewee described leakage in company's systems
LOCAL/NATIONAL COMPANY	Company only sells locally and within the country

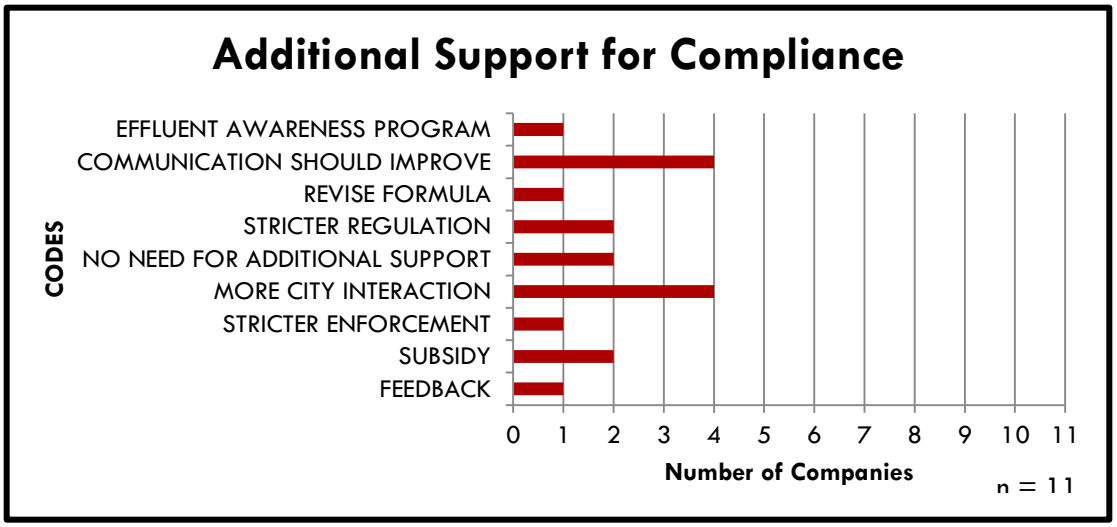
MINIMAL EDUCATION	Company has minimal education materials for water conservation
MINIMAL EFFLUENT TREATMENT	Company's effluent is treated minimally
MINIMAL REUSE	Company reuses water on a small scale
MINIMAL TRAINING	Company has minimal employee training for water use & conservation
MINIMAL UNDERSTANDING OF CHARGES	Interviewee described minimal understanding of charges from city
MINIMAL WATER USE	Interviewee described that company uses only minimal water
MONITORING DEVICE	Company has monitoring devices for water consumption
MONOPOLY	The company is a monopoly
MORE CITY INTERACTION	Interviewee described desire for the city to share more suggestions and knowledge
NO HARD COPY REGULATIONS	
NO NEED FOR ADDITIONAL SUPPORT	Interviewee did not feel additional support from city was needed
NO TRAINING	Company does not have employee training for water use & conservation
NO VALUE IN TRAINING	Interviewee expressed that there is no value in employee training for water use & conservation
NO WATER SAVING MEASURES	Company has not implemented any water saving measures
NOT COMPLYING TO REGULATIONS	Interviewee expressed that company is not complying to regulations
OLD SYSTEM	Interviewee described that company system is old or outdated
OUTDATED TREATMENT PLANT	Interviewee described that company treatment plant is old or outdated
PIPE FAILURE	Interviewee described failures in system piping
PLANT UPGRADE	Company has plans to upgrade plant
POOR RELATIONSHIP WITH CITY	Interviewee expressed poor relationships with city
POSITIVE CITY INTERACTION	Interviewee described positive interactions with city

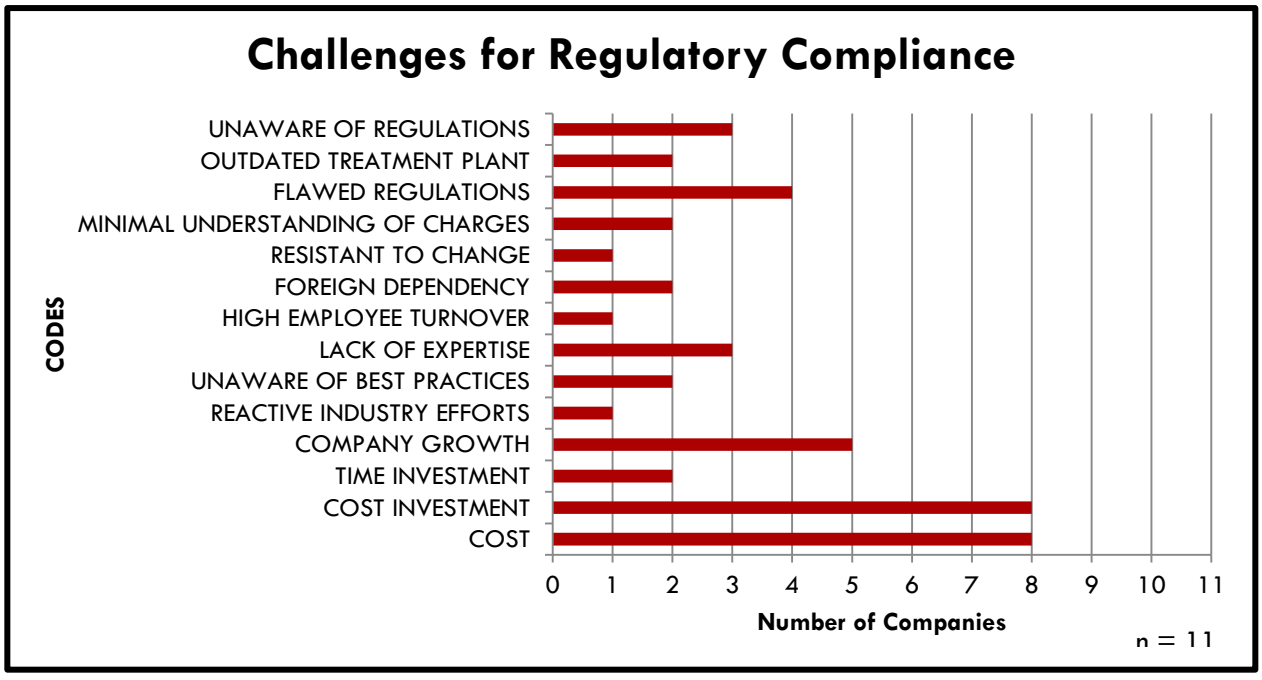
POSITIVE RELATIONSHIP WITH CITY	Interviewee expressed positive relationship with city
PRESSURE FLUCTUATIONS	Interviewee described fluctuations in city's water supply pressure
PROFIT	Interviewee expressed importance of company profit
PUBLIC OBLIGATION	Interviewee expressed company's obligation to the public
REACTIVE CITY EFFORTS	City does not address challenges before they grow
REACTIVE INDUSTRY EFFORTS	Company does not address challenges before they grow
REGULATE URBANIZATION	Interviewee expressed importance of city regulating rate of urbanization
RESEARCHING BEST PRACTICES	Company is in the process of researching best practices to implement
RESISTANT TO CHANGE	Interviewee described challenges with resistance to change
REVISE FORMULA	Interviewee expressed that the formula be revised
SATISFACTORY COMMUNICATION	Interviewee expressed satisfaction with city's communication
SCREENS	Company's effluent is treated by screens
SETTLING TANK	Company's effluent is treated in a settling tank
SOFT COPY REGULATIONS	The interviewee expressed that they have access to soft copy regulations
STORMWATER TREATMENT	Company treats storm water runoff
STRICTER ENFORCEMENT	Interviewee expressed need for stricter enforcement of city regulations
STRICTER REGULATIONS	Interviewee expressed the need for stricter city regulations
SUBSIDY	Interviewee described a desire for a monetary reward from city
SUPPORT FROM CITY	
SUPPORT REGULATIONS	Interviewee expressed support of city's regulations
SUPPORTS RESIDENTIAL RATIONING	Interviewee expressed support of residential water rationing

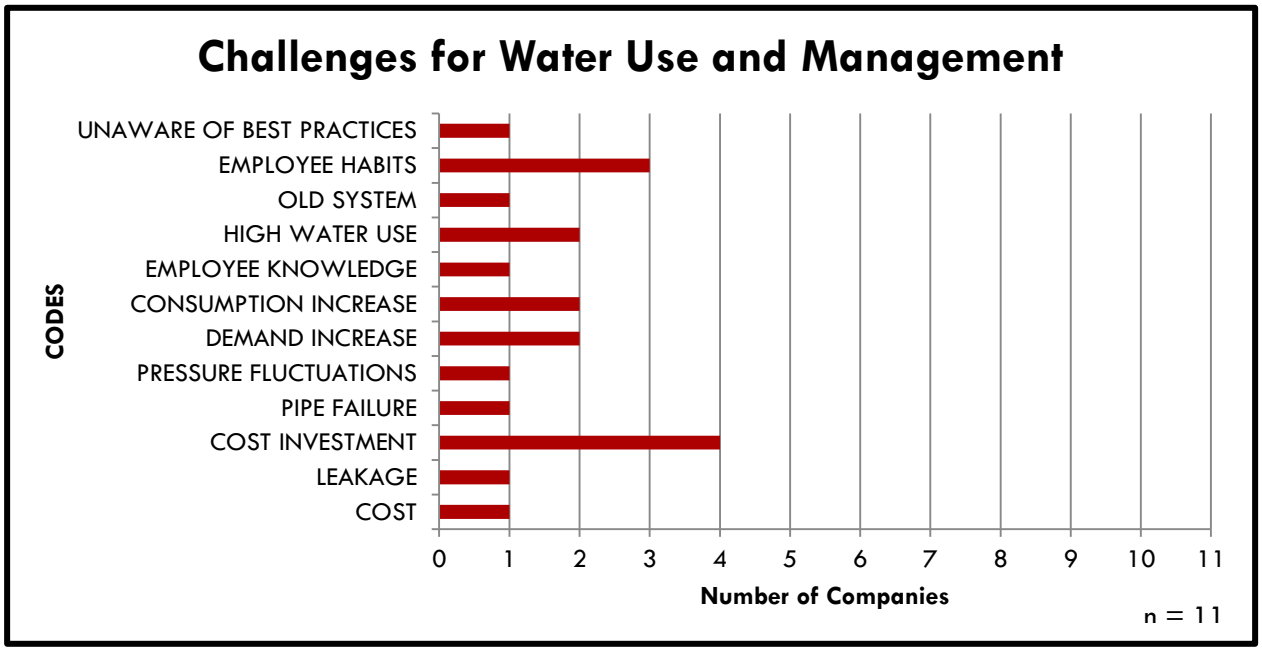
TIME INVESTMENT	Interviewee described burden of time investment
TRAINING IMPROVEMENT	Interviewee expressed that employee training for water use & conservation should be improved
TRAINING PROGRAM	Company has implemented an employee training program
UNAWARE OF BEST PRACTICES	Interviewee expressed that company is not aware of best practices to implement
UNAWARE OF REGULATIONS	Interviewee expressed that the company was unaware of the effluent regulations
UNCLEAR FORMULA	Interviewee expressed the confusing nature of the formula
UNDERSTAND FORMULA	Interviewee understands city formula
UNFAIR FORMULA	Interviewee expressed dissatisfaction for the city's charge formula due to unfairness
UNSATISFACTORY COMMUNICATION	Interviewee expressed dissatisfaction with city's communication
WARY OF INDUSTRIAL RATIONING	Interviewee expressed concern with implementation of industrial water rationing
WARY OF INDUSTRIAL REGULATIONS	Interviewee expressed concern with implementation of industrial effluent and water regulations
WASTEWATER TREATMENT PLANT	Company runs a wastewater treatment plant for treating effluent
WATER SAVING DEVICES	Company uses water-saving devices to save water in manufacturing process

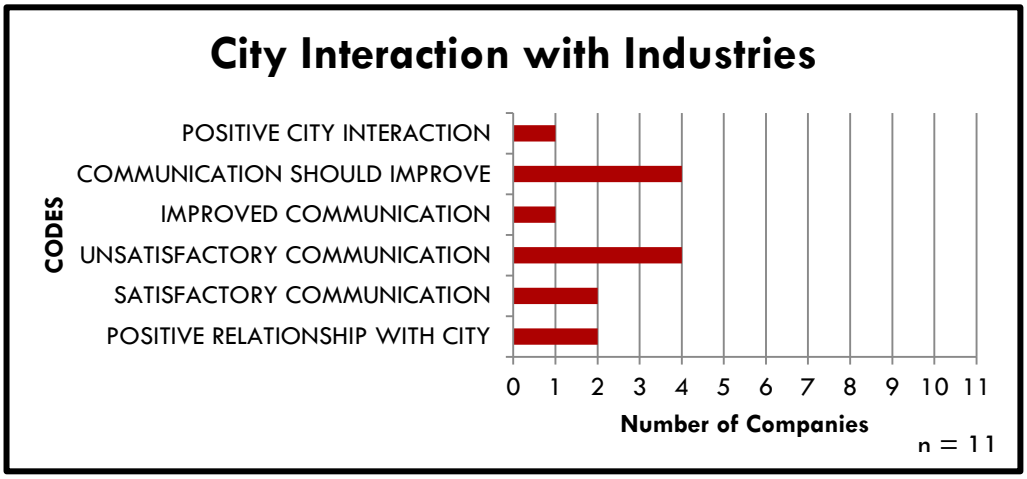
Appendix V: Graphical Representations of Coding Analysis

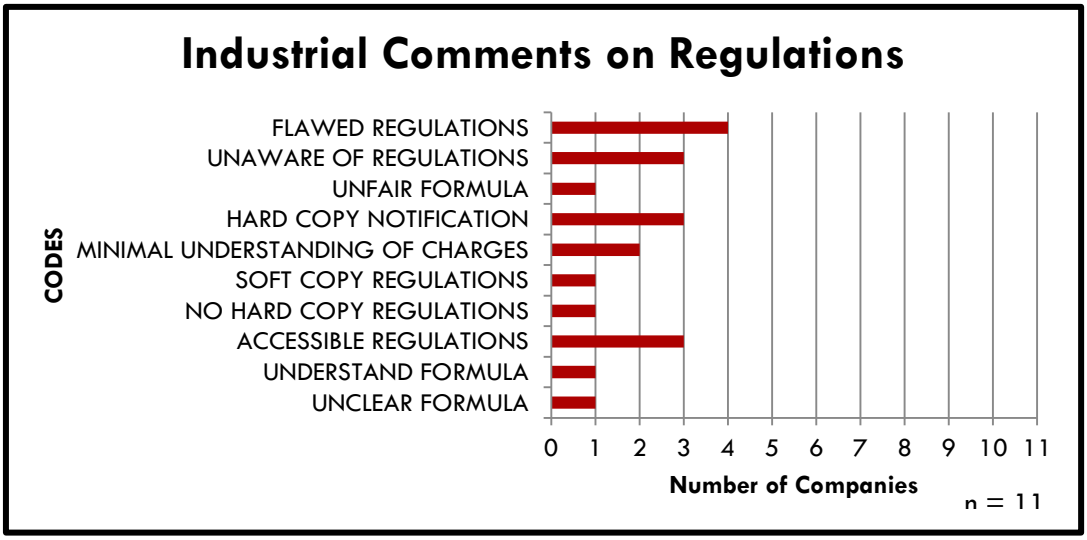


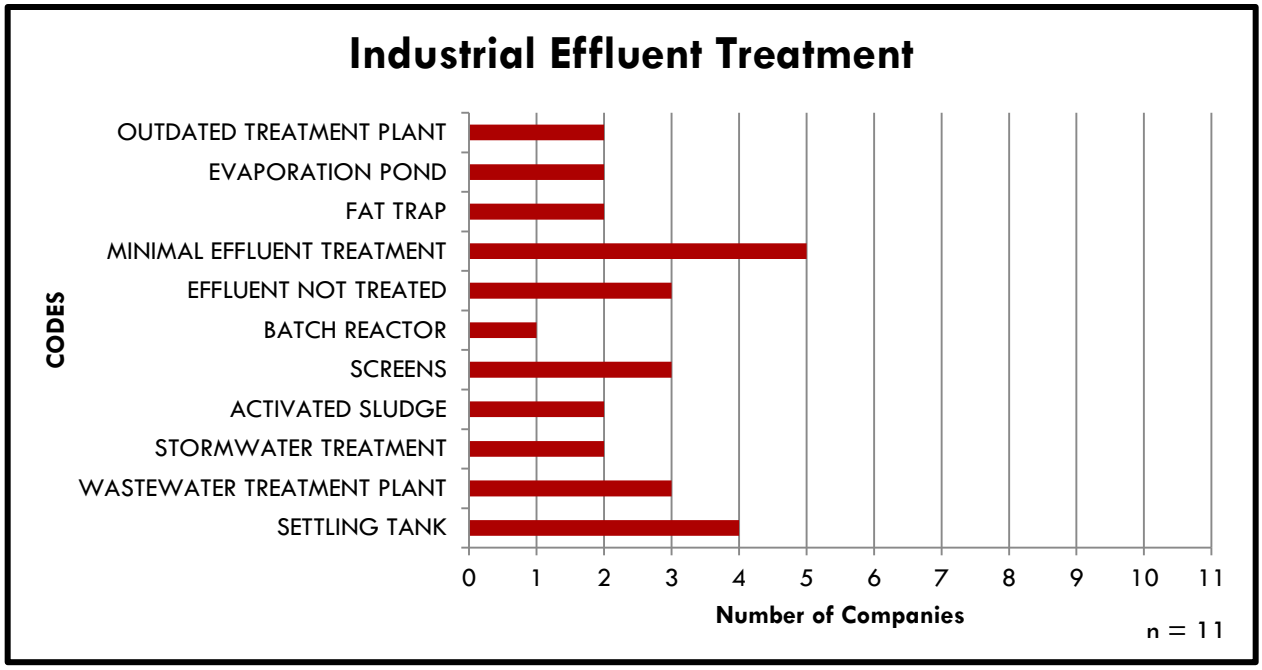


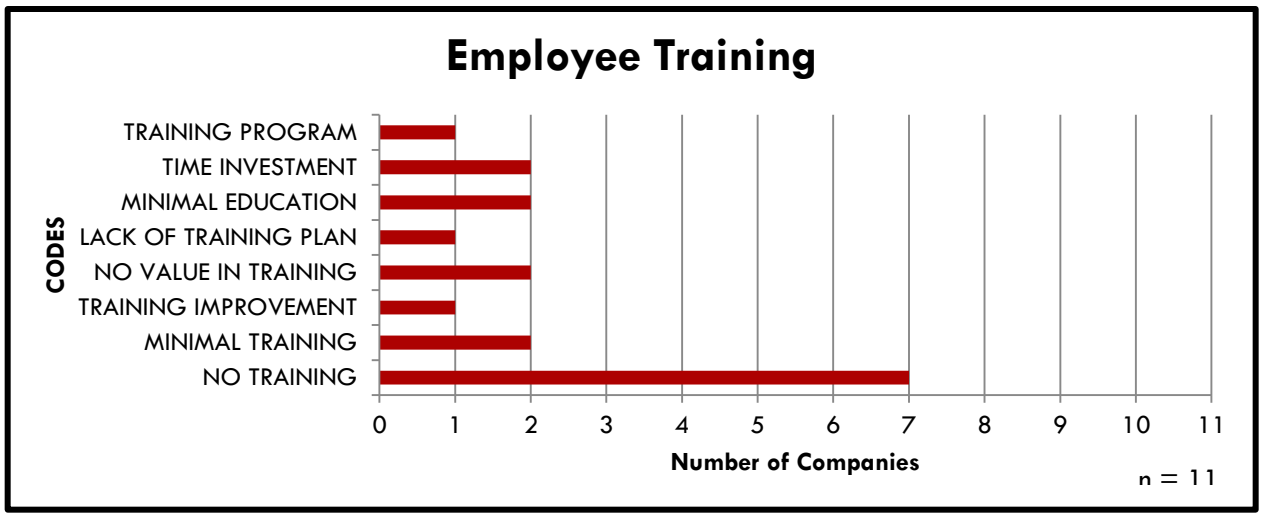


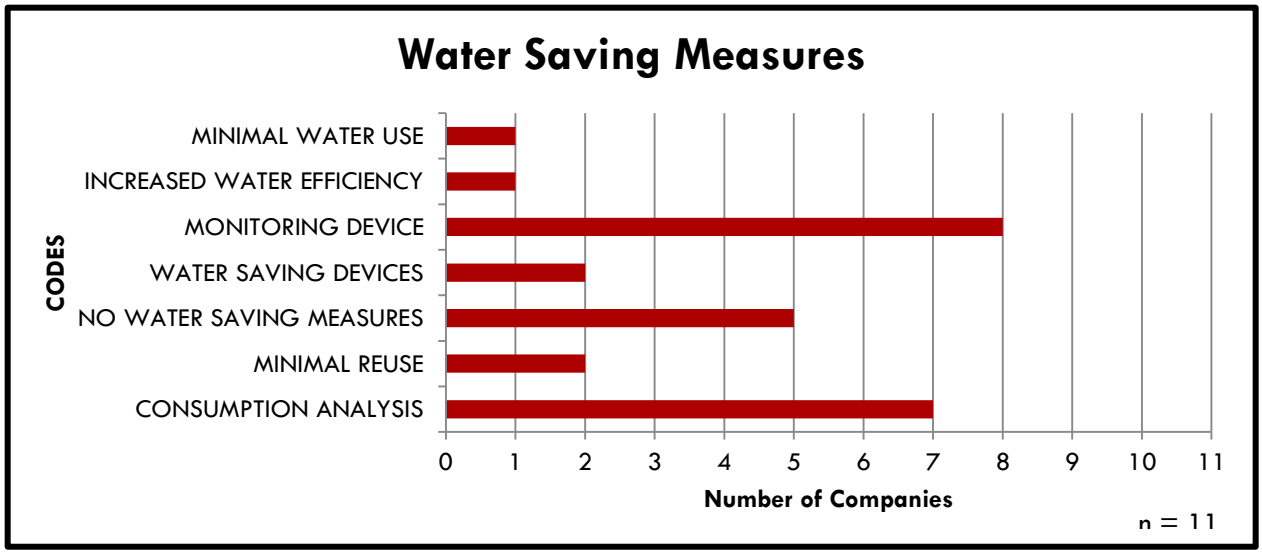

Challenges for Water Use and Management
UNAWARE OF BEST PRACTICES
EMPLOYEE HABITS
OLD SYSTEM
HIGH WATER USE
EMPLOYEE KNOWLEDGE
CONSUMPTION INCREASE
DEMAND INCREASE
PRESSURE FLUCTUATIONS
PIPE FAILURE
COST INVESTMENT
LEAKAGE
COST
CODES
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11

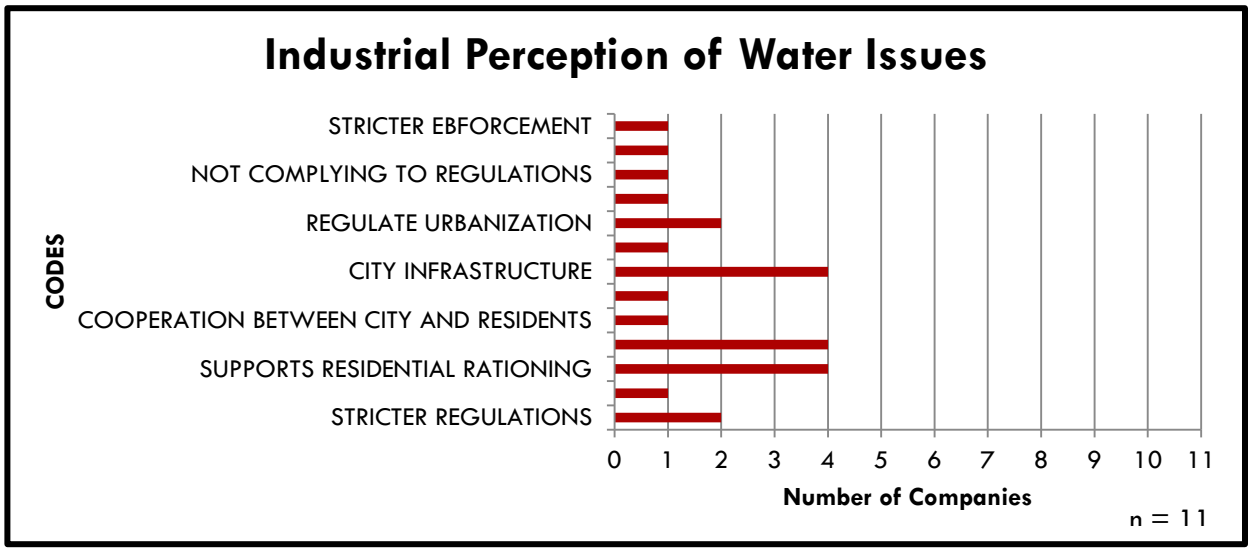

City Interaction with Industries
POSITIVE CITY INTERACTION
COMMUNICATION SHOULD IMPROVE
IMPROVED COMMUNICATION
UNSATISFACTORY COMMUNICATION
SATISFACTORY COMMUNICATION
POSITIVE RELATIONSHIP WITH CITY
CODES
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11


Industrial Comments on Regulations
FLAWED REGULATIONS
UNAWARE OF REGULATIONS
UNFAIR FORMULA
HARD COPY NOTIFICATION
MINIMAL UNDERSTANDING OF CHARGES
SOFT COPY REGULATIONS
NO HARD COPY REGULATIONS
ACCESSIBLE REGULATIONS
UNDERSTAND FORMULA
UNCLEAR FORMULA
CODES
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11


Industrial Effluent Treatment
OUTDATED TREATMENT PLANT
EVAPORATION POND
FAT TRAP
MINIMAL EFFLUENT TREATMENT
EFFLUENT NOT TREATED
BATCH REACTOR
SCREENS
ACTIVATED SLUDGE
STORMWATER TREATMENT
WASTEWATER TREATMENT PLANT
SETTLING TANK
CODES
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11


Employee Training
TRAINING PROGRAM
TIME INVESTMENT
MINIMAL EDUCATION
LACK OF TRAINING PLAN
NO VALUE IN TRAINING
TRAINING IMPROVEMENT
MINIMAL TRAINING
NO TRAINING
CODES
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11


Water Saving Measures
MINIMAL WATER USE
INCREASED WATER EFFICIENCY
MONITORING DEVICE
WATER SAVING DEVICES
NO WATER SAVING MEASURES
MINIMAL REUSE
CONSUMPTION ANALYSIS
CODES
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11


Industrial Perception of Water Issues
CODES
STRICTER EBFORCEMENT
NOT COMPLYING TO REGULATIONS
REGULATE URBANIZATION
CITY INFRASTRUCTURE
COOPERATION BETWEEN CITY AND RESIDENTS
SUPPORTS RESIDENTIAL RATIONING
STRICTER REGULATIONS
0 1 2 3 4 5 6 7 8 9 10 11
Number of Companies
n = 11

Appendix W: Written Survey Outline for Industrial Personnel

Industrial Employee Water Survey

DATE: **TIME:** **COMPANY:**

The City of Windhoek Department of Infrastructure, Water & Technical Services is conducting the following water survey in conjunction with Worcester Polytechnic Institute, USA. The purpose of this survey is to gain information on industrial employee opinions on current water conditions in Windhoek. Through this survey, the City will be able to develop new awareness campaigns and efforts towards efficient water provision in Windhoek.

All survey responses are anonymous and confidential. You may refuse to answer any or all of the questions at any time. Simply leave them blank.

Demographic Information: Please indicate responses to the following questions.

Please mark your gender:
☐Male ☐Female

Please mark your suburb of residence:
☐Goreangab ☐Havana ☐Katutura ☐Khomasdal ☐Okuryangava ☐Wanaheda ☐Windhoek ☐ Other: _____

Please mark your age range:
☐15-20 ☐21-25 ☐26-30 ☐31-35 ☐36-40 ☐41-45 ☐46-50 ☐51-55 ☐56+

Please mark the highest level of education you have received:
☐No school ☐Primary school ☐Secondary school ☐Some university ☐University degree

---

Question #1: In your daily duties in the workplace, how often do you consider the following topics?
(1= never; 5=often times each day)

Water saving measures:	1	2	3	4	5
Environmental impact:	1	2	3	4	5
Economic success of the company:	1	2	3	4	5
Recycling:	1	2	3	4	5

Question #2: Thinking of Windhoek as a whole, how important are the following topics to you?
(1=not important; 5=very important)

Quality of the city's drinking water:	1	2	3	4	5
Quantity of the city's water supply:	1	2	3	4	5
Economic prosperity:	1	2	3	4	5
Availability of jobs:	1	2	3	4	5
Preserving the natural environment:	1	2	3	4	5

Survey continued on back

Question #3: Where do you believe Windhoek's water sources come from? *(Please check all that apply)*

- ☐ Underground aquifers
- ☐ Reservoirs/dams
- ☐ Rivers
- ☐ Recycled water

Question #4: Do you believe Windhoek is experiencing water scarcity and drought conditions?
(If no, please skip to question 7)

☐ Yes ☐ No

Question #5: To what degree do you believe that the drought conditions are serious?
(1 not serious; 5 = very serious) 1 2 3 4 5

Question #6: Which solutions would you support to alleviate the water scarcity problems in Windhoek?
(Please check all that apply)

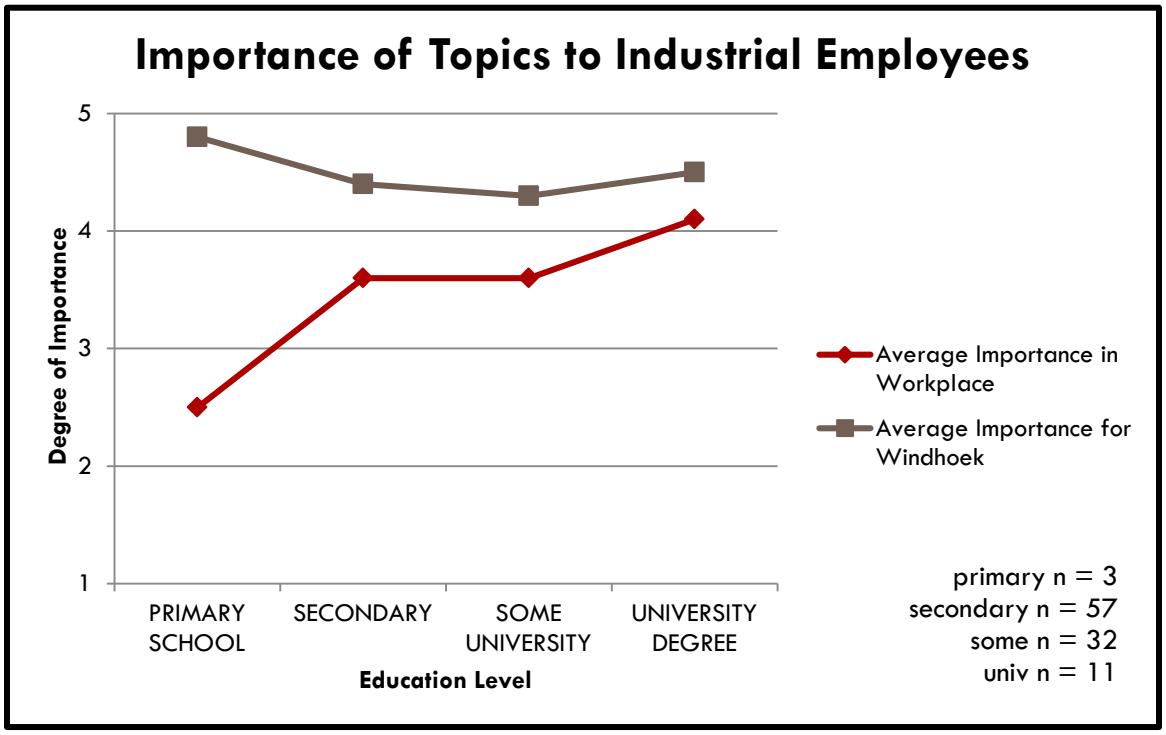
- ☐ Water rationing
- ☐ Mandatory implementation of water-saving devices
- ☐ Pipelines from northern rivers (increase in water price)
- ☐ Decreasing the ranges of water tariffs

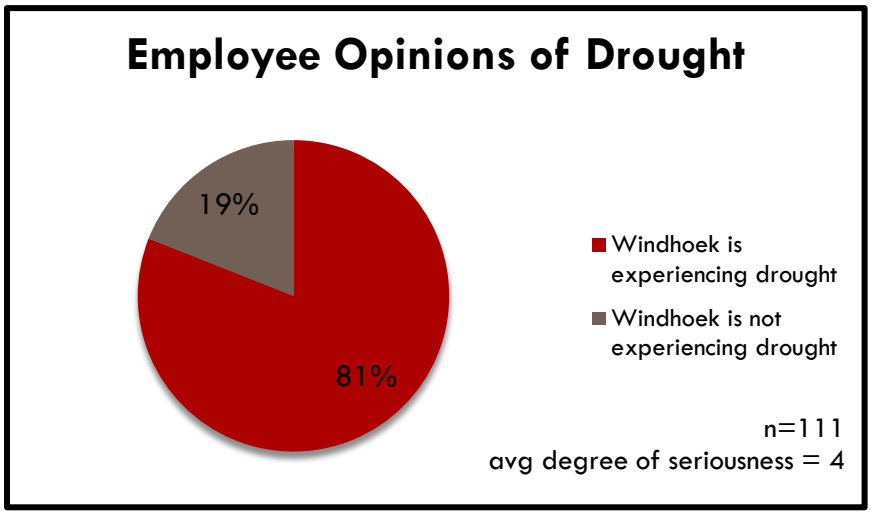
Question #7: Which water-saving measures do you practice in your personal life?
(Please check all that apply)

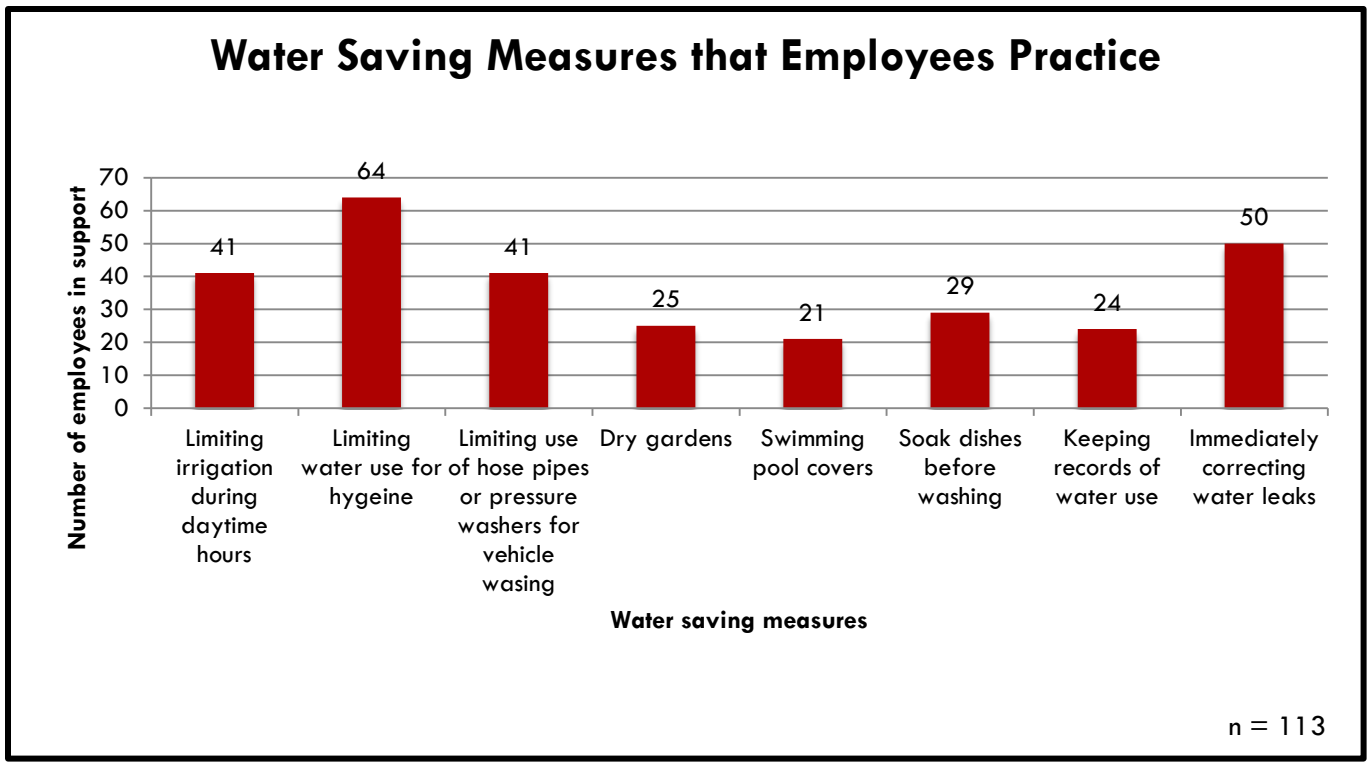
- ☐ Dry gardens
- ☐ Swimming pool covers
- ☐ Limit water use for hygiene (short showers, turning tap off when brushing teeth, etc)
- ☐ Limiting irrigation during daytime hours
- ☐ Limiting use of hose pipes or pressure washers for vehicle washing
- ☐ Soak dishes before washing
- ☐ Keeping records of water use
- ☐ Immediately correcting water leaks
- ☐ Other: _____

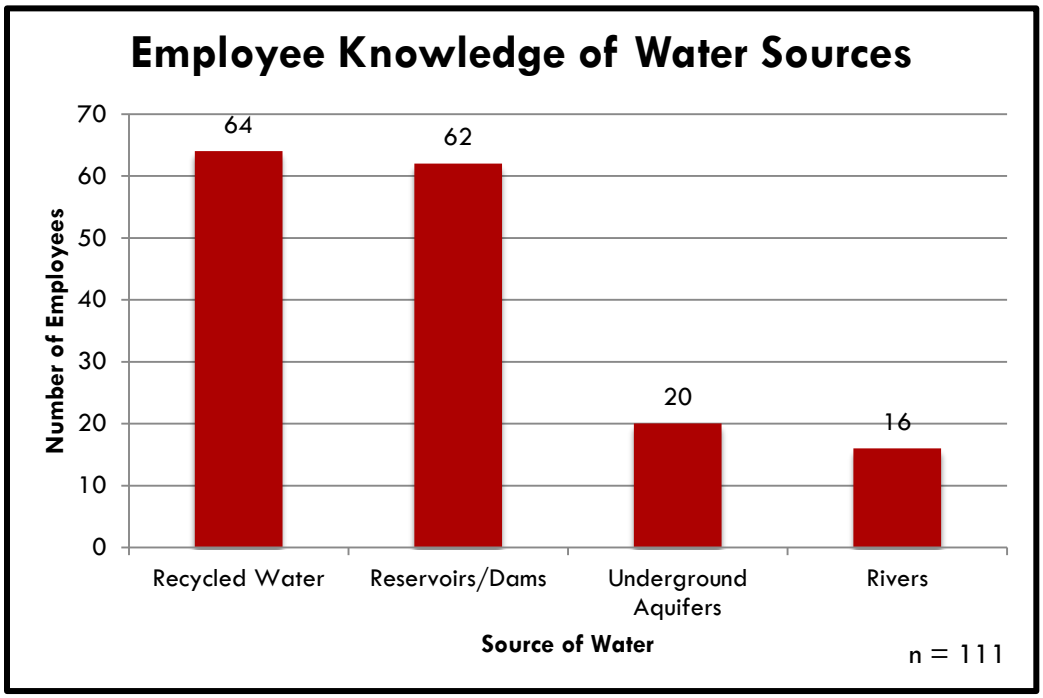
Thank you for taking the time to complete this survey. Your input is greatly appreciated.

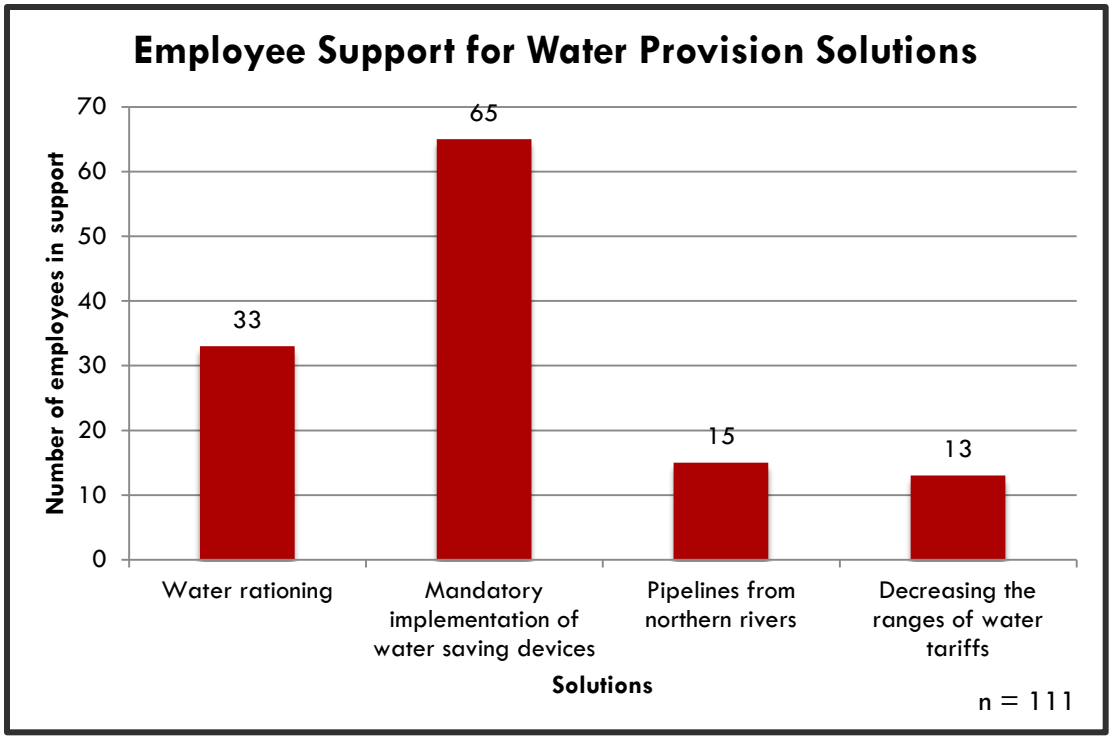
Appendix X: Graphical Representation of Survey Analysis



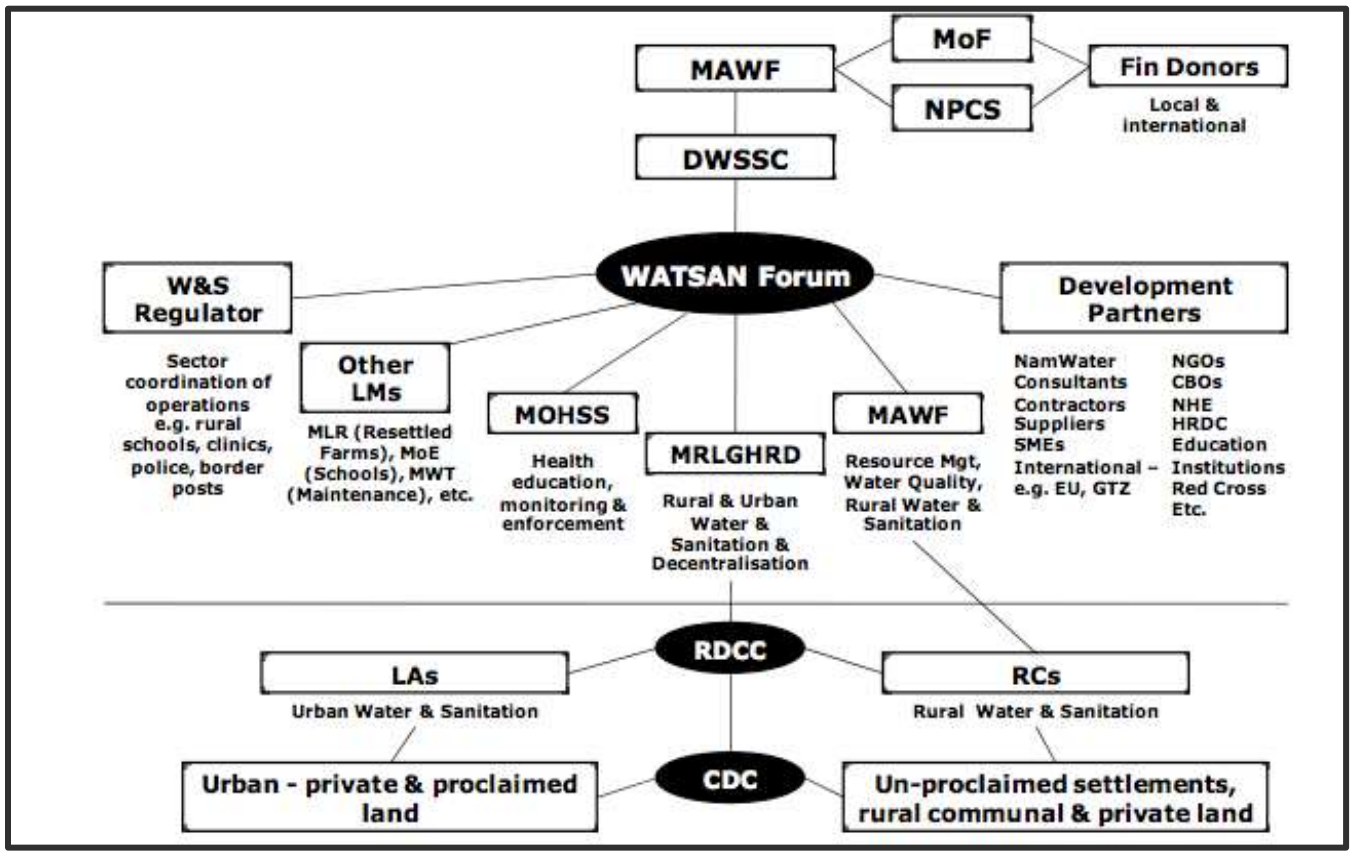



Water Saving Measures that Employees Practice
Number of employees in support
70
60
50
40
30
20
10
0
41
64
41
25
21
29
24
50
Limiting irrigation during daytime hours
Limiting water use for hygeine
Limiting use of hose pipes or pressure washers for vehicle wasing
Dry gardens
Swimming pool covers
Soak dishes before washing
Keeping records of water use
Immediately correcting water leaks
Water saving measures
n = 113


Employee Knowledge of Water Sources
Number of Employees
70
60
50
40
30
20
10
0
64
62
20
16
Recycled Water
Reservoirs/Dams
Underground Aquifers
Rivers
Source of Water
n = 111


Employee Support for Water Provision Solutions
Number of employees in support
70
60
50
40
30
20
10
0
33
65
15
13
Water rationing
Mandatory implementation of water saving devices
Pipelines from northern rivers
Decreasing the ranges of water tariffs
Solutions
n = 111

Appendix Y: 2009 Water Sanitation Forum Organizational Flowchart



(MINISTRY OF AGRICULTURE, WATER & FORESTRY, 2009).